Radiological Health Data

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VOLUME IV, NUMBER 4

APRIL 1963

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

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SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Quick and sensitive detection of fission product activity fluctuations in the environment is possible through a program of continuous surveillance of gross beta activity in air and precipitation. The information obtained through surveillance does not alone permit evaluation of biological effects due to fallout but it does form the basis of alerting systems and can be used as a rough guide to when and where more extensive monitoring of radioactivity in food, milk, and water is necessary.

December 1962 gross beta concentrations are presented here in reports from the Radiation Surveillance Network, 80th Meridian (West) Sampling Program, Canadian Radioactive Fallout Study Program, and the Mexican Radioactive Fallout Program. Data from the National Air Sampling Network for fourth quarter 1962 and from the National Committee for Nuclear Energy in Rome, Italy for all of 1961 are also presented. Because of differences in equipment and techniques, the results of one network's surveillance are not directly comparable with those of another. However, intercalibration factors for comparing the results of three networks have been determined in a study conducted by Lockhart and Patterson of the U.S. Naval Research Laboratory (*1*, *2*). Using these factors, a 1.00 $\mu\mu c/m^3$ reading by the Canadian Air Monitoring Network would correspond to a 0.65 $\mu\mu c/m^3$ reading by the Radiation Surveillance Network and a 1.12 $\mu\mu c/m^3$ reading by the NRL 80th Meridan Network (*2*). These intercalibration factors are subject to the uncertainty of air volume measurements and may not be expected to hold for very young fission products.

REFERENCES

(*1*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Washington, D.C. (November 13, 1962).

(*2*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: Intercalibration of Some Air Monitoring Systems, *Radiological Health Data*, *3*:466–70, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (December 1962).

RADIATION SURVEILLANCE NETWORK
December 1962

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed among the fifty States, Guam, and Puerto Rico (see figure 1). These stations are manned predominantly by State Health Department personnel.

Air

Daily 24-hour air samples are collected by a high-volume air sampler with a 4-inch diameter carbon-loaded cellulose dust filter. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable

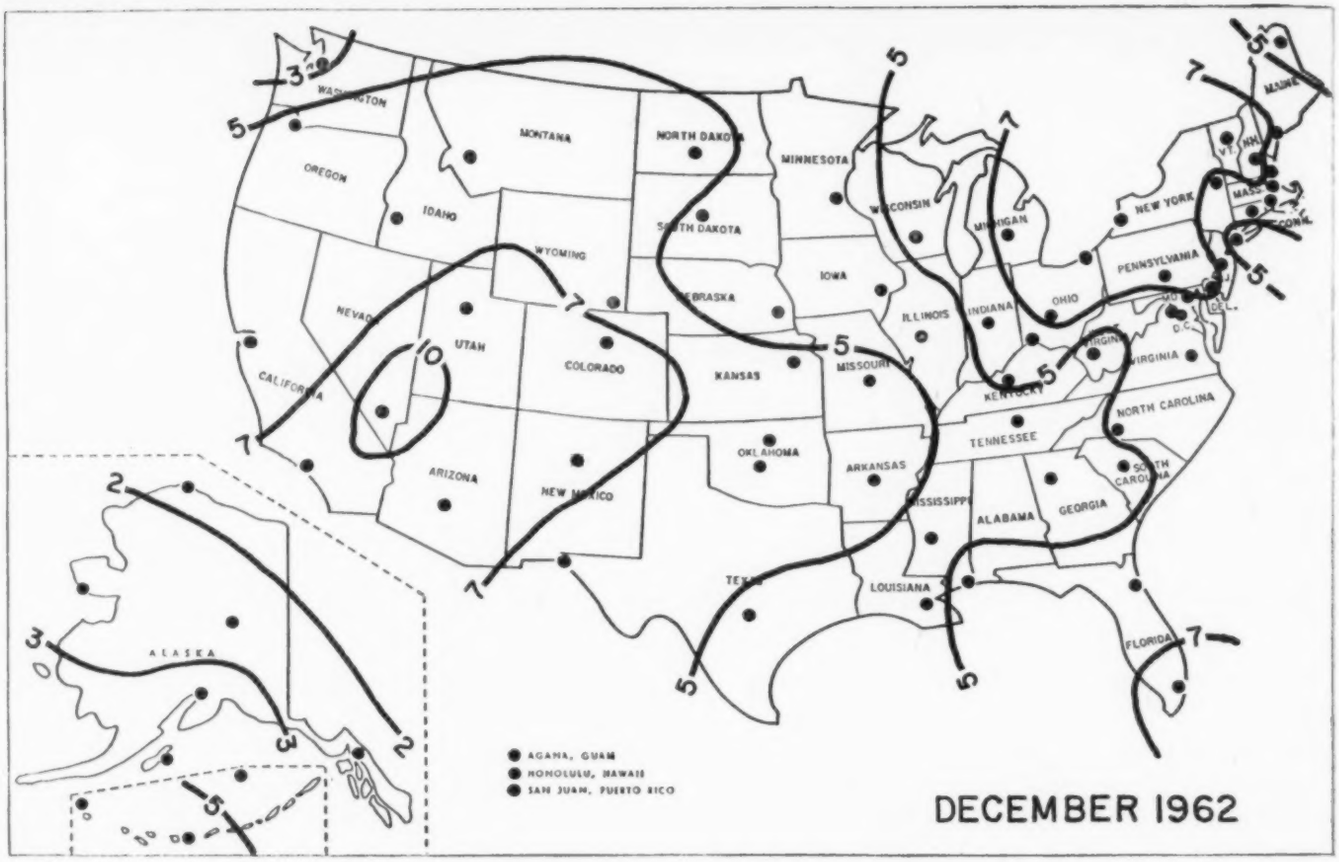

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS AND AVERAGE FISSION PRODUCT BETA CONCENTRATIONS IN AIR ($\mu\mu c/m^3$)

survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} known activity source. This determination is usually made about 5 hours after end of collection to eliminate interference from naturally-occurring radon daughters. The Network's station operators contribute to a daily national report by telephoning their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. The two counts, separated by a 7-day interval, are used to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2}$ = constant)* The daily concentrations and estimated age are reported by the Public Health Service (*1*).

The average fission-product beta concentrations in surface air during December 1962, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1 and presented by means of concentration contours in figure 1.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels with collection areas of 0.4 m^2. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples. If the collected sample is between 200 and 500 ml, the entire sample is evaporated; if less than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation

* In this expression, A is the activity and T is the time after fission product formation.

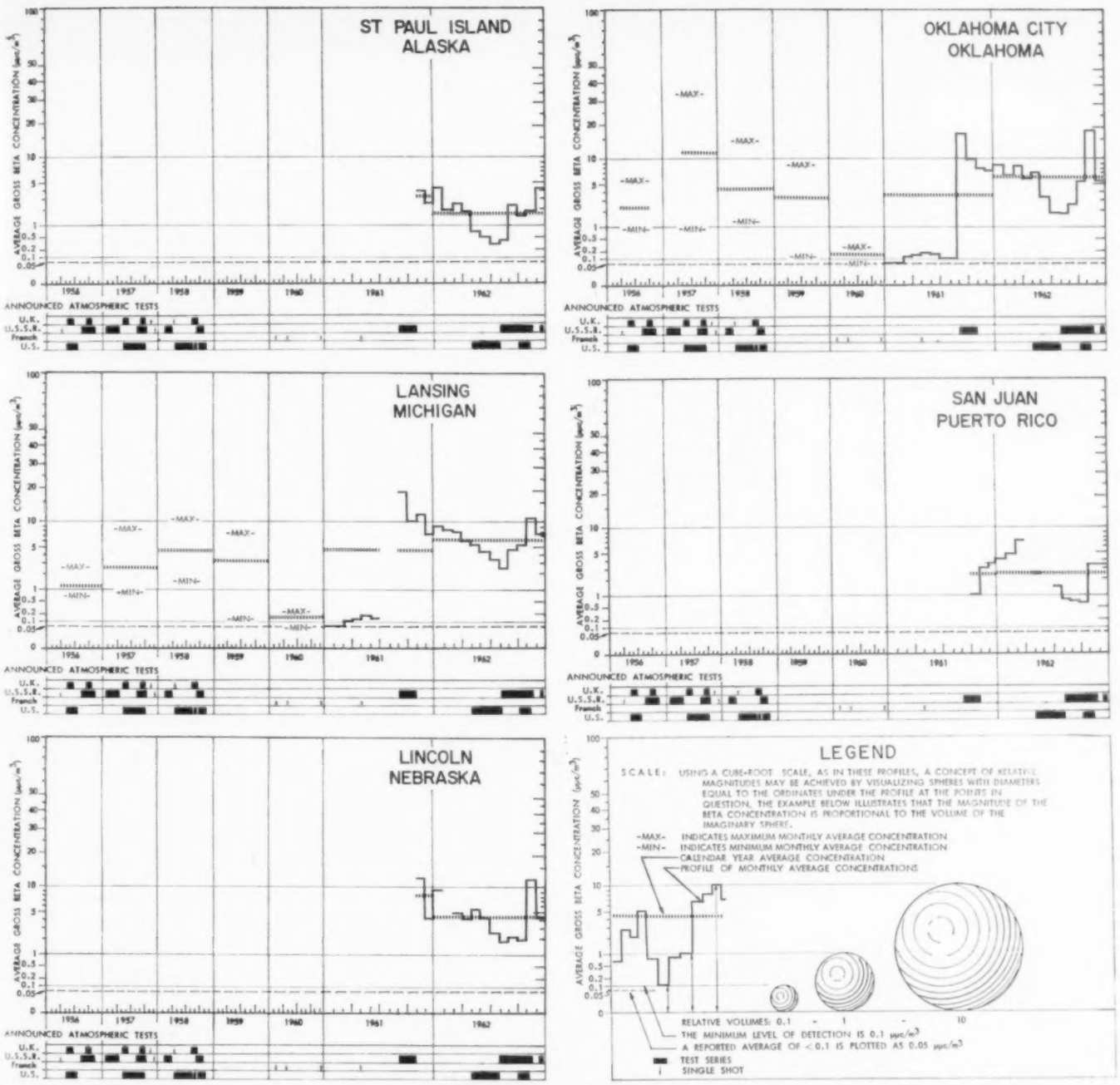
ST PAUL ISLAND
ALASKA
OKLAHOMA CITY
OKLAHOMA
LANSING
MICHIGAN
SAN JUAN
PUERTO RICO
LINCOLN
NEBRASKA
LEGEND
SCALE: USING A CUBE-ROOT SCALE, AS IN THESE PROFILES, A CONCEPT OF RELATIVE MAGNITUDES MAY BE ACHIEVED BY VISUALIZING SPHERES WITH DIAMETERS EQUAL TO THE ORDINATES UNDER THE PROFILE AT THE POINTS IN QUESTION. THE EXAMPLE BELOW ILLUSTRATES THAT THE MAGNITUDE OF THE BETA CONCENTRATION IS PROPORTIONAL TO THE VOLUME OF THE IMAGINARY SPHERE.
-MAX- INDICATES MAXIMUM MONTHLY AVERAGE CONCENTRATION
-MIN- INDICATES MINIMUM MONTHLY AVERAGE CONCENTRATION
CALENDAR YEAR AVERAGE CONCENTRATION
PROFILE OF MONTHLY AVERAGE CONCENTRATIONS
RELATIVE VOLUMES: 0.1 - 1 - 10
THE MINIMUM LEVEL OF DETECTION IS 0.1 μμc/m³
A REPORTED AVERAGE OF < 0.1 IS PLOTTED AS 0.05 μμc/m³
TEST SERIES
SINGLE SHOT
AVERAGE GROSS BETA CONCENTRATION (μμc/m³)
ANNOUNCED ATMOSPHERIC TESTS
U.K.
U.S.S.R.
French
U.S.
1956
1957
1958
1959
1960
1961
1962

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1956–DECEMBER 1962

is reported, but no analysis is made. December 1962 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter (μμc/liter) and millimicrocuries per square meter (mμc/m²), are presented in table 2.

Profiles

Profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. Profiles of 5 stations, updated through December 1962, are shown in figure 2. An index to the *RHD* issue having the most recent profile for each station is given in the last column of table 1.

REFERENCE

(1) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D.C. (Distribution by Official Request).

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, DECEMBER 1962

[Concentrations in $\mu\mu c/m^3$]

Station location		Number of Samples	Maximum	Minimum	Average[a]	Last profile in RHD
Alaska:	Adak	31	17	0.18	5.2	Nov. 62
	Anchorage	25	8.8	0.49	3.6	Jul. 62
	Attu	31	12	<0.10	5.1	Dec. 62
	Fairbanks	23	4.6	1.3	2.4	Aug. 62
	Juneau	26	5.1	0.19	2.2	Sep. 62
	Kodiak	26	15	<0.10	3.3	Oct. 62
	Nome	26	9.0	0.36	2.6	Feb. 63
	Point Barrow Island	1	1.9	1.9	1.9	Mar. 63
	St. Paul Island	15	11	2.1	4.2	Apr. 63
Ariz:	Phoenix	28	21	3.8	8.8	Aug. 62
Ark:	Little Rock	31	12	0.57	5.9	Sep. 62
Calif:	Berkeley	26	17	0.87	5.1	Sep. 62
	Los Angeles	19	33	2.6	8.9	Feb. 63
Colo:	Denver	25	20	2.3	8.2	Oct. 62
Conn:	Hartford	26	17	1.1	6.0	Sep. 62
Del:	Dover	19	29	2.0	9.1	[b]
D.C:	Washington	31	26	0.72	5.4	Mar. 63
Fla:	Jacksonville	26	15	0.40	6.8	Sep. 62
	Miami	26	19	2.9	7.6	Feb. 63
Ga:	Atlanta	28	13	0.17	4.0	Jul. 62
Guam:	Agana	—	—	—	—	Mar. 63
Hawaii:	Honolulu	28	16	0.56	3.4	Nov. 62
Idaho:	Boise	31	14	1.8	6.8	Dec. 62
Ill:	Springfield	29	11	0.26	4.9	Oct. 62
Ind:	Indianapolis	21	28	1.9	5.3	Jul. 62
Iowa:	Iowa City	30	12	1.7	4.3	Nov. 62
Kans:	Topeka	26	16	2.5	5.7	Jul. 62
Ky:	Frankfort	24	19	1.6	5.1	Mar. 63
La:	New Orleans	26	10	0.29	4.5	Nov. 62
Maine:	Augusta	30	30	0.80	7.0	Mar. 63
	Presque Isle	11	14	1.3	4.8	[b]
Md:	Baltimore	18	18	1.7	6.2	Sep. 62
	Rockville	13	13	1.4	5.8	[b]
Mass:	Lawrence	31	19	0.95	5.6	Aug. 62
	Winchester	25	30	1.8	9.0	[b]
Mich:	Lansing	30	25	1.2	7.8	Apr. 63
Minn:	Minneapolis	28	14	1.3	4.0	Mar. 63
Miss:	Jackson	27	10	0.28	4.4	Mar. 63
	Pascagoula	18	12	0.92	7.0	Nov. 62
Mo:	Jefferson City	23	10	1.0	5.2	Dec. 62
Mont:	Helena	24	13	1.3	5.7	Nov. 62
Nebr.	Lincoln	24	7.3	2.0	4.2	Apr. 63
Nev:	Las Vegas	26	48	4.6	12	[b]
N.H:	Concord	16	18	1.8	8.9	[b]
N.J:	Trenton	31	30	1.5	6.7	Oct. 62
N.Mex:	Santa Fe	29	22	1.1	7.1	Dec. 62
N.Y:	Albany	26	25	1.1	6.8	Jul. 62
	Buffalo	25	24	0.26	7.3	[b]
	New York	14	8.5	0.62	3.6	Dec. 62
N.C:	Gastonia	26	20	0.37	6.2	Oct. 62
N.Dak:	Bismarck	29	11	2.5	5.5	Feb. 63
Ohio:	Cincinnati	17	10	1.9	5.1	Jul. 60
	Columbus	23	32	2.6	8.8	Feb. 63
	Painesville	31	30	0.34	8.2	[b]
Okla:	Oklahoma City	29	11	0.41	5.2	Apr. 62
	Ponca City	27	6.3	0.32	2.8	Oct. 62
Ore:	Portland	27	19	1.3	6.4	Oct. 62
Pa:	Harrisburg	23	25	0.55	8.1	Dec. 62
P.R:	San Juan	24	7.6	0.70	3.5	Apr. 63
R.I:	Providence	26	24	1.9	6.6	Nov. 62
S.C:	Columbia	26	14	0.49	4.6	Dec. 62
S.Dak:	Pierre	29	8.1	2.0	4.5	Sep. 62
Tenn:	Nashville	30	12	0.69	4.9	Feb. 63
Tex:	Austin	30	12	0.25	4.9	Aug. 62
	El Paso	30	10	3.2	6.0	Feb. 63
Utah:	Salt Lake City	31	15	2.2	7.3	Jul. 62
Vt:	Barre	30	30	1.2	9.0	[b]
Va:	Richmond	26	24	1.1	5.5	Aug. 62
Wash:	Seattle	26	6.3	0.81	2.9	Jul. 62
W.Va:	Charleston	26	13	1.1	4.6	[b]
Wisc:	Madison	30	18	1.5	6.3	Aug. 62
Wyo:	Cheyenne	30	13	2.1	6.2	Aug. 62
Network average					5.8	

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

[b] Profile is scheduled for a future issue.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, DECEMBER 1962

Station location		Average concentration ($\mu\mu c$/liter)	Total deposition ($m\mu c/m^2$)
Alaska:	Adak	[a]	—
	Anchorage	2,200	7.1
	Attu	—	—
	Fairbanks	1,500	24
	Juneau	1,000	33
	Kodiak	—	—
	Nome	—	—
	Point Barrow Island	—	—
	St. Paul Island	—	—
Ariz:	Phoenix	—	—
Ark:	Little Rock	1,900	77
Calif:	Berkeley	460	18
	Los Angeles	—	—
Colo:	Denver	2,200	3.6
Conn:	Hartford	3,500	170
Del:	Dover	—	—
D.C:	Washington	2,300	160
Fla:	Jacksonville	1,000	28
	Miami	—	—
Ga:	Atlanta	480	7.2
Guam:	Agana	—	—
Hawaii:	Honolulu	—	—
Idaho:	Boise	1,600	11
Ill:	Springfield	—	—
Ind:	Indianapolis	2,000	21
Iowa:	Iowa City	1,900	7.7
Kans:	Topeka	2,800	19
Ky:	Frankfort	1,800	38
La:	New Orleans	1,700	110
Maine:	Augusta	1,600	260
	Presque Isle	1,200	21
Md:	Baltimore	4,900	98
	Rockville	—	—
Mass:	Lawrence	1,600	170
	Winchester	2,300	200
Mich:	Lansing	1,800	36
Minn:	Minneapolis	1,300	4.1
Miss:	Jackson	1,000	43
	Pascagoula	—	—
Mo:	Jefferson City	1,100	44
Mont:	Helena	4,400	30
Nebr:	Lincoln	4,200	44
Nev:	Las Vegas	—	—
N.H:	Concord	—	—
N.J:	Trenton	1,800	21
N.Mex:	Santa Fe	3,600	63
N.Y:	Albany	1,200	55
	Buffalo	2,000	110
	New York	—	—
N.C:	Gastonia	520	39
N.Dak:	Bismarck	3,900	17
Ohio:	Cincinnati	—	—
	Columbus	1,400	50
	Painesville	2,600	310
Okla:	Oklahoma City	2,900	12
	Ponca City	1,800	74
Ore:	Portland	2,000	95
Pa:	Harrisburg	—	—
P.R:	San Juan	480	65
R.I:	Providence	3,600	130
S.C:	Columbia	1,900	75
S.Dak:	Pierre	1,800	4.6
Tenn:	Nashville	1,500	36
Tex:	Austin	1,500	110
	El Paso	2,800	54
Utah:	Salt Lake City	2,700	5
Vt:	Barre	1,500	110
Va:	Richmond	1,900	160
Wash:	Seattle	2,100	120
W.Va:	Charleston	2,300	120
Wisc:	Madison	1,800	28
Wyo:	Cheyenne	4,100	1.7

[a] Dash indicates no evaporated sample received.

THE 80TH MERIDIAN (WEST) SAMPLING PROGRAM
December 1962

U.S. Naval Research Laboratory

Since 1956 the U.S. Naval Research Laboratory (NRL)* has been making radioactivity measurements of surface air samples collected at various sites (see figure 3) near the 80th Meridian (West). Interested agencies of the United States, Canada, Ecuador, Peru, Bolivia, and Chile participate in the 80th Meridian program by collecting air samples and forwarding them to NRL for analysis. The Division of Biology and Medicine, U.S. Atomic Energy Commission, provides partial financial support for this program.

The sampling procedure involves drawing air continuously for a 7-day period at a rate of approximately 1200 cubic meters per day through an 8-inch diameter, high-efficiency filter, using a positive-displacement blower. After the 7-day period, the filter is removed and forwarded to NRL for assay of gross beta activity. A minimum of 2 weeks after collection is allowed for decay of short-lived radionuclides. December 1962 data in table 3 are not extrapolated to time of collection.

* *Editor's note:* Effective January 1, 1963, administration of the 80th Meridian (West) Sampling Program was turned over to the Health and Safety Laboratory, Division of Biology and Medicine, AEC, by the U.S. Naval Research Laboratory.

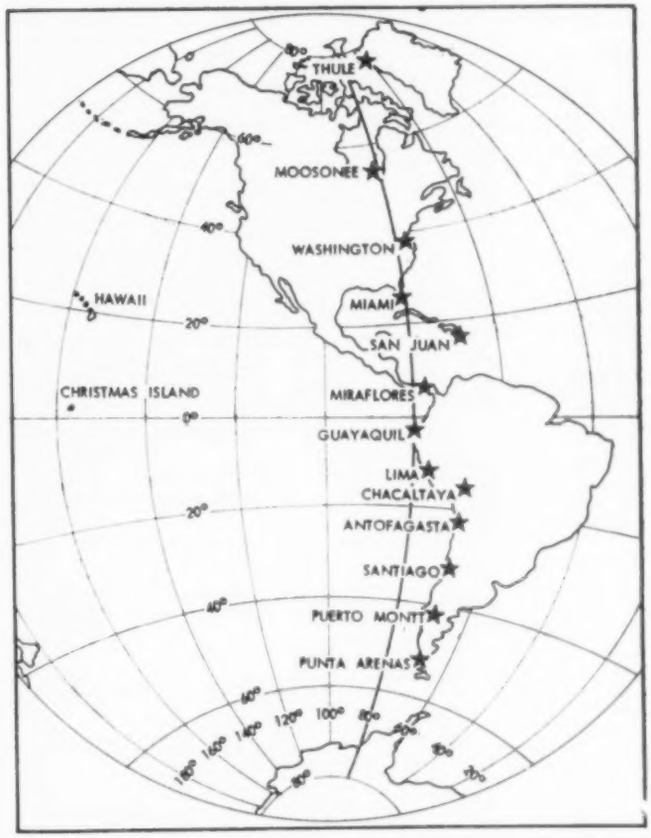

FIGURE 3. — ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

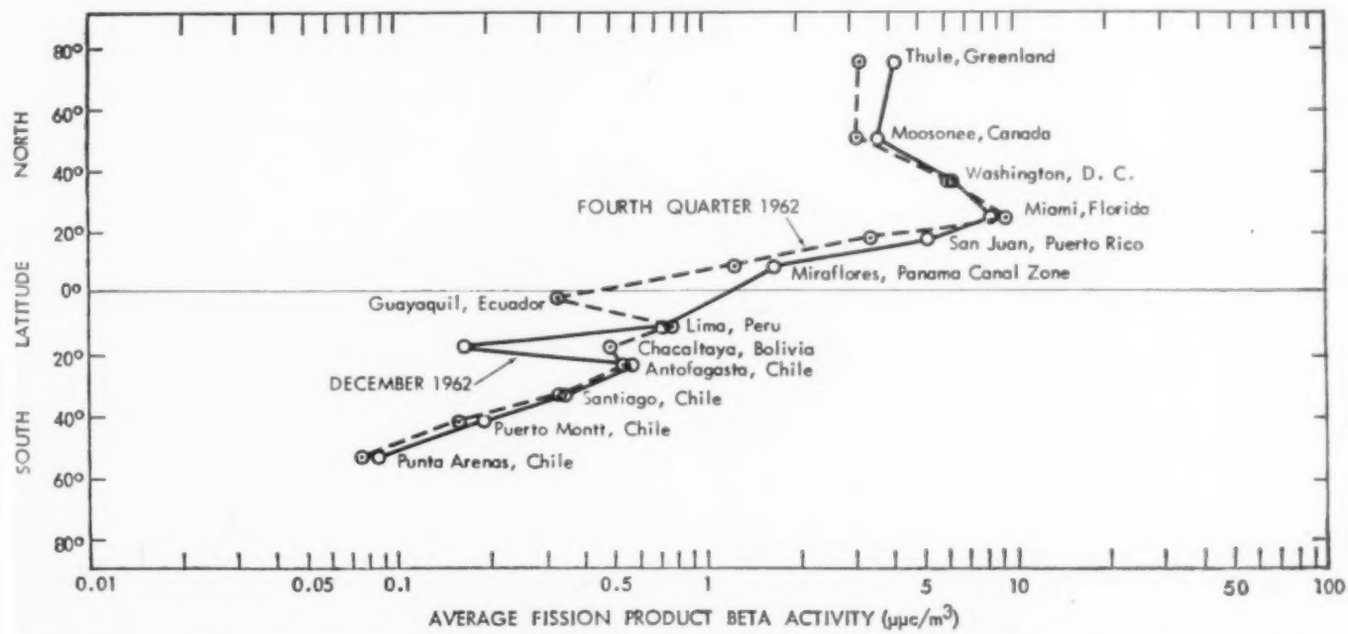

FIGURE 4.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST), DECEMBER 1962

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NRL, DECEMBER 1962[a]

[Average concentrations in $\mu\mu c/m^3$]

Day	Punta Arenas, Chile	Puerto Montt, Chile	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	San Juan, P.R.	Mauna Loa, Hawaii[c]	Miami, Florida	Washington, D.C.	Moosonee, Canada	Thule, Greenland
1 2 3	0.050	0.126	0.327	0.477	0.468	[b]—	—	2.034	5.175	5.265	8.730	14.895	6.975	4.995
4 5 6 7 8 9 10	0.126	0.229	0.349	0.429	0.245	—	—	1.026	3.465	4.545	7.605	6.570	2.871	5.445
11 12 13 14 15 16 17	0.097	—	0.295	0.664	0.110	0.734	—	1.539	3.465	1.836	11.925	4.590	3.429	4.680
18 19 20 21 22 23 24	—	—	0.407	0.748	0.073	0.814	—	1.346	8.910	3.092	8.100	3.902	3.380	3.537
25 26 27 28 29 30 31	0.058	0.261	—	0.489	0.112	0.788	—	2.484	4.018	—	5.355	7.020	3.380	2.691
Weighted average	0.088	0.223	0.350	0.572	0.167	0.778	—	1.660	5.220	3.452	8.280	6.435	3.622	4.176

[a] The average concentration determined from a given sample is placed at the center of a rectangle which indicates the length and dates of the sampling period. Station averages for the month were determined by weighting the sample average according to the number of days in the sampling period or that portion of the sampling period occurring in December 1962.

[b] Dash indicates samples were not received.

[c] Mauna Loa data have been included for comparison with Chacaltaya, Bolivia. Both are high elevation stations (3400 and 5200 meters, respectively) and about equally distant north and south of the equator.

NATIONAL AIR SAMPLING NETWORK
Fourth Quarter and Annual Summary 1962

Division of Air Pollution,
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

Gross Beta Activity in Air

NASN stations (see figure 5) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. There are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

At the stations, continuous 24-hour samples of suspended particulate matter are taken. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory in Cincinnati, Ohio. Fourth quarter and annual summary 1962 data are presented in tables 4 and 5.

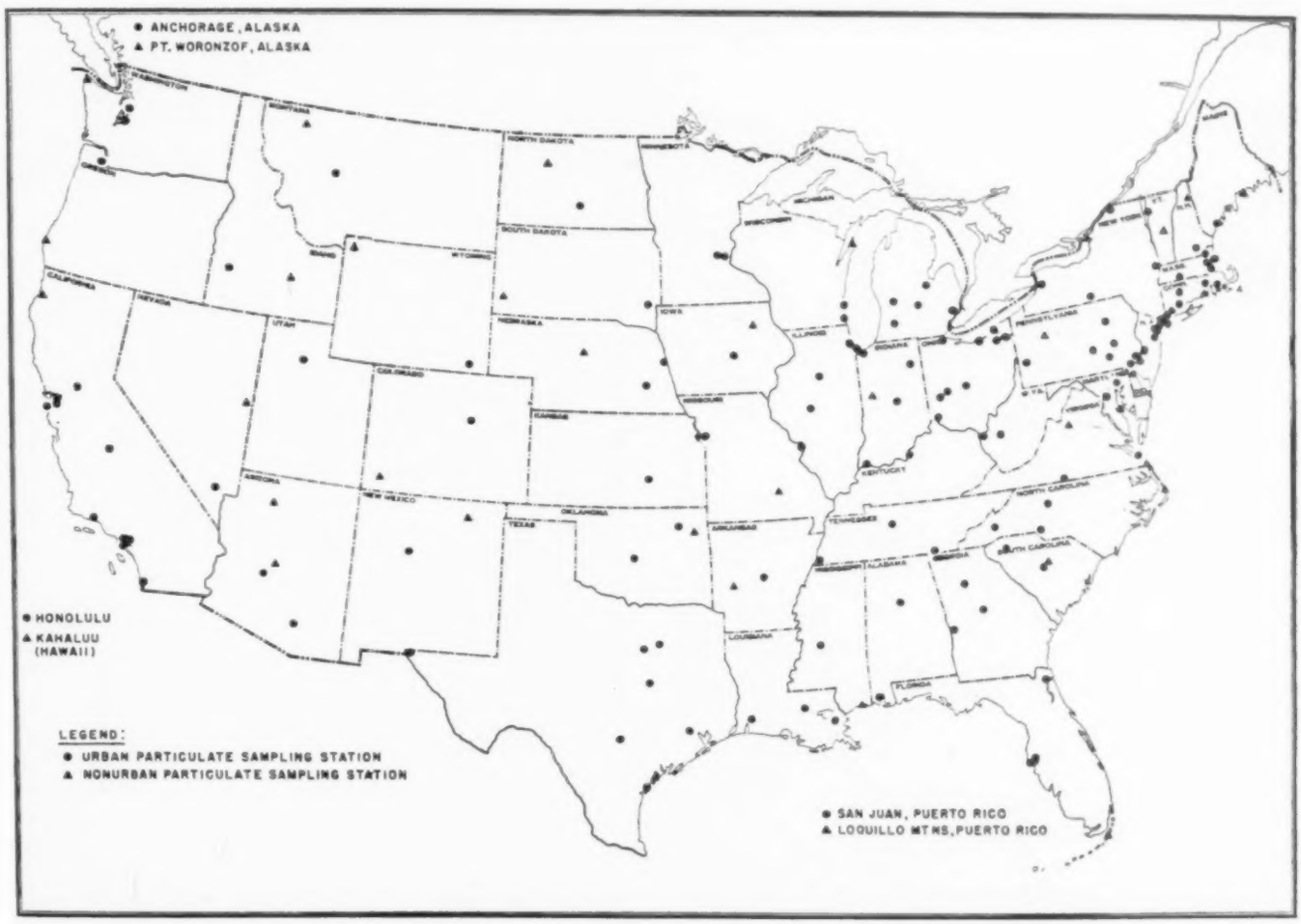

FIGURE 5.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS, 1962

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, FOURTH QUARTER 1962

[Concentrations in pc/m³]

Station location	Number of Samples	Minimum	Maximum	Average
Ala:				
Birmingham	6	1.8	10.0	5.5
Mobile	5	4.9	15.4	10.6
Alaska:				
Anchorage	6	2.5	5.2	4.1
Pt Woronzof*	7	0.7	8.2	3.2
Ariz:				
Grand Canyon Pk*	6	2.2	9.1	5.9
Maricopa Co*	6	3.9	16.7	9.0
Phoenix	5	3.7	10.8	8.4
Tucson	6	4.2	10.2	7.1
Ark:				
Little Rock	5	1.0	10.4	5.8
Montgomery Co*	6	0.6	20.0	7.0
Calif:				
Burbank	7	2.7	16.4	8.1
Fresno	6	2.0	12.0	5.3
Humboldt Co*	4	0.3	7.6	3.0
Los Angeles	6	3.9	15.1	7.6
Oakland	6	2.2	16.8	7.1
Pasadena	6	4.3	31.2	10.6
Richmond	6	0.5	6.6	3.3
Sacramento	6	0.7	6.1	2.8
San Diego	6	2.6	18.7	8.0
San Francisco	6	1.8	13.6	5.2
Santa Barbara	6	3.6	11.5	6.8
Colo:				
Denver	6	1.9	17.0	5.8
Montezuma Co*	7	1.4	17.8	8.9
Conn:				
Bridgeport	6	4.6	12.3	8.1
Hartford	6	2.1	9.1	5.4
New Haven	7	2.1	10.1	5.4
Stamford	6	1.4	7.7	4.9
Del:				
Wilmington	5	3.4	12.8	7.2
D.C:				
Washington	5	1.7	11.0	6.2
Fla:				
Florida Keys*	6	4.4	11.7	7.3
Jacksonville	7	0.4	21.4	9.4
Orlando	6	3.9	33.0	15.9
St. Petersburg	5	4.8	21.6	10.4
Tampa	5	2.3	18.3	9.0
Ga:				
Atlanta	5	3.5	18.2	9.6
Columbus	7	1.6	14.9	8.0
Macon	6	4.4	8.1	5.9
Hawaii:				
Honolulu	6	2.1	11.1	4.9
Kahaluu*	6	2.3	16.8	5.6
Idaho:				
Boise	6	3.4	18.5	9.6
Butte Co*	4	2.1	14.4	8.3
Ill:				
Chicago	6	3.5	12.7	7.1
Cicero	2	4.2	9.0	6.6
Peoria	5	2.1	11.1	6.7
Springfield	5	3.2	10.5	6.5
Ind:				
East Chicago	4	1.5	15.7	7.7
Evansville	7	1.6	8.1	4.7
Fort Wayne	5	3.2	15.1	6.5
Gary	4	2.6	4.0	3.7
Indianapolis	6	1.0	10.1	5.7
Parke Co*	6	3.7	10.7	8.1
Iowa:				
Delaware Co*	6	1.2	12.6	5.9
Des Moines	6	0.9	7.3	4.0
Kans:				
Kansas City	5	2.4	12.7	5.5
Wichita	7	3.1	12.4	7.9
Ky:				
Louisville	3	2.3	9.7	6.0
La:				
Baton Rouge	5	4.4	21.0	9.0
Lake Charles	6	2.4	40.5	14.1
New Orleans	6	1.4	19.4	8.5
Maine:				
Acadia Nat Park*	6	1.6	9.2	4.2
Portland	7	2.7	15.8	6.2
Md:				
Baltimore	6	2.7	6.4	4.9
Calvert Co*	5	1.2	12.1	5.6
Mass:				
Boston	6	1.1	14.1	5.8
Fall River	5	2.4	13.4	7.5
Lawrence	5	1.0	14.0	5.3
Lynn	4	2.7	18.1	7.1
Quincy	6	2.3	19.8	10.4
Somerville	7	2.4	19.3	7.6
Springfield	7	4.5	10.9	6.8
Mich:				
Detroit	6	1.8	8.5	4.8
Grand Rapids	5	0.4	4.4	2.2
Kalamazoo	5	4.0	14.0	7.2
Lansing	6	0.2	12.4	4.6
Saginaw	6	0.3	8.9	4.2
Minn:				
Minneapolis	6	3.7	7.9	5.5
St. Paul	6	1.4	10.1	6.3
Miss:				
Jackson	7	1.7	12.5	6.2
Jackson Co*	4	0.4	8.2	4.5
Mo:				
Kansas City	5	3.4	18.0	7.4
Shannon Co*	5	4.0	10.3	8.1
St. Louis	6	2.0	12.4	7.4
Mont:				
Glacier Nat. Pk*	5	2.0	9.5	6.1
Helena	6	4.1	11.1	7.3
Nebr:				
Lincoln	7	1.1	16.7	8.2
Omaha	6	3.4	19.6	11.0
Thomas Co*	7	1.6	14.2	7.5
Nev:				
Las Vegas	6	5.8	24.0	13.1
White Pine Co*	5	5.2	21.0	11.9
N.H:				
Coos Co*	4	3.6	8.3	7.0
N.J:				
Camden	6	4.1	27.3	11.4
East Orange	7	0.4	11.4	3.5
Elizabeth	6	1.5	14.6	5.9
Newark	7	2.0	8.7	5.5
Trenton	6	1.8	20.0	7.2
N.Mex:				
Albuquerque	7	4.2	16.0	7.6
Colfax Co*	7	4.8	16.4	7.7
N.Y:				
Cape Vincent	5	5.6	9.9	7.2
Glen Cove*	5	3.4	10.8	5.7
Massena	6	0.7	9.2	4.4
New York City	6	1.1	13.0	7.2
Niagara Falls	2	2.8	6.4	4.6
Rochester	6	0.6	8.7	4.5
Troy	6	1.2	7.7	4.8
N.C:				
Asheville	6	1.7	18.4	8.1
Cape Hatteras*	4	7.0	29.0	13.3
Charlotte	6	3.5	9.4	7.4
Winston-Salem	6	1.0	18.1	7.3
N.Dak:				
Bismarck	5	2.5	29.8	11.4
Ward Co*	5	5.0	20.1	8.8
Ohio:				
Akron	6	3.0	7.5	5.4
Cincinnati	5	2.7	7.2	4.2
Cleveland	5	3.7	6.8	5.3
Columbus	5	1.6	14.8	6.3
Dayton	5	2.3	9.3	5.7
Lorain	6	1.5	15.5	6.5
Springfield	6	2.0	12.5	6.5
Toledo	7	0.7	12.3	4.4
Youngstown	7	2.5	12.2	6.6
Okla:				
Cherokee Co*	6	0.5	15.3	6.8
Oklahoma City	6	0.4	11.1	7.1
Tulsa	5	2.6	24.5	8.9
Ore:				
Curry Co*	4	0.6	7.0	3.6
Portland	4	1.8	15.1	6.9
Pa:				
Clarion Co*	4	4.5	7.0	6.1
Harrisburg	5	3.3	9.7	6.8
Lancaster	6	1.6	14.4	8.5
Philadelphia	6	2.1	11.9	6.6
Pittsburgh	6	2.8	12.5	6.3
Reading	6	2.2	12.2	6.6
Wilkes-Barre	7	2.2	10.0	5.5
P.R:				
Loquillo Mountains*	3	0.6	2.3	1.3
San Juan	5	1.3	3.9	2.4
R.I:				
Providence	7	2.1	7.0	4.1
Washington Co*	6	1.2	3.9	1.9
S.C:				
Columbia	5	2.3	7.6	5.8
Greenville	6	3.6	20.0	9.1
Richland Co*	5	1.9	8.1	5.0
S.Dak:				
Black Hills Forest*	6	3.7	15.7	7.4
Sioux Falls	6	2.3	11.1	6.1

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, FOURTH QUARTER 1962—Con.

[Concentrations in pc/m³]

Station location	Number of Samples	Minimum	Maximum	Average	Station location	Number of Samples	Minimum	Maximum	Average
Tenn:					Va:				
Chattanooga	6	3.5	8.7	6.2	Danville	6	1.9	11.9	6.1
Memphis	6	3.7	11.8	7.3	Norfolk	5	2.9	9.2	6.6
Nashville	6	3.7	11.7	7.6	Shenandoah Nat. Pk*	6	3.8	10.8	6.8
Texas:					Wash:				
Aransas Co*	6	4.4	15.4	8.4	Clallam Co*	4	2.4	9.6	4.9
Corpus Christi	6	1.6	18.6	7.6	Seattle	6	1.0	9.8	4.0
Dallas	6	2.1	21.0	8.6	Tacoma	6	1.9	5.2	3.7
El Paso	6	4.4	15.5	8.9	W.Va:				
Ft. Worth	7	1.4	23.0	7.0	Charleston	6	4.2	6.5	5.1
Houston	5	0.4	21.0	7.0	Huntington	4	4.9	7.5	6.2
San Antonio	6	0.5	13.0	4.5	Wisc:				
Waco	6	0.3	91.0	20.1	Door Co*	6	0.6	14.0	5.3
Utah:					Milwaukee	6	2.7	18.5	6.6
Salt Lake City	6	7.4	18.6	12.0	Racine	6	1.6	15.0	4.7
Vt:					Wyo:				
Burlington	5	0.9	6.2	4.4	Cheyenne	6	3.5	19.3	10.8
Orange Co*	6	0.9	8.1	4.7					

* Nonurban Station.

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, ANNUAL SUMMARY, 1962

[Concentrations in pc/m³]

Station location	Number of Samples	Minimum	Maximum	Average	Station location	Number of Samples	Minimum	Maximum	Average
Ala:					Ind:				
Birmingham	26	0.3	15.7	7.0	East Chicago	19	1.5	15.7	5.1
Mobile	25	1.1	16.6	7.6	Evansville	24	0.2	10.1	4.6
Alaska:					Fort Wayne	25	1.7	15.8	6.1
Anchorage	25	0.2	11.1	4.1	Gary	22	1.5	12.8	5.4
Pt. Woronzof*	25	<0.1	17.6	4.2	Indianapolis	26	1.0	12.7	6.3
Ariz:					Parke Co*	26	1.9	11.4	6.9
Grand Canyon Pk*	26	0.5	23.8	9.3	Iowa:				
Maricopa Co*	26	0.9	33.8	10.2	Delaware Co*	23	1.2	16.1	6.1
Phoenix	25	0.7	21.6	9.7	Des Moines	26	0.9	13.1	5.1
Tucson	25	2.5	18.2	8.9	Kans:				
Ark:					Kansas City	24	0.7	12.7	5.5
Little Rock	23	0.2	15.6	6.5	Wichita	25	1.7	16.2	7.3
Montgomery Co*	23	0.3	20.0	5.9	Ky:				
Calif:					Louisville	19	1.8	13.8	5.7
Burbank	22	2.5	20.2	6.7	La:				
Fresno	26	2.0	23.3	6.6	Baton Rouge	24	1.2	25.7	8.7
Humboldt Co*	19	0.2	9.7	3.0	Lake Charles	26	0.5	40.5	7.5
Los Angeles	24	1.2	20.1	6.6	New Orleans	26	0.7	19.4	5.9
Oakland	25	0.7	16.8	5.1	Maine:				
Pasadena	23	1.8	31.2	6.8	Acadia Nat. Park*	22	0.2	13.9	5.2
Richmond	24	0.1	11.5	3.4	Portland	24	0.9	15.8	5.4
Sacramento	26	0.7	19.6	5.2	Md:				
San Diego	25	0.9	18.7	6.6	Baltimore	26	0.6	16.7	5.7
San Francisco	26	0.5	25.5	5.6	Calvert Co*	24	0.7	12.1	6.2
Santa Barbara	25	0.7	21.4	6.1	Mass:				
Colo:					Boston	24	1.0	15.2	6.2
Denver	24	1.2	17.0	5.3	Fall River	24	0.1	15.5	7.1
Montezuma Co*	25	1.4	17.8	8.6	Lawrence	25	0.5	14.3	6.5
Conn:					Lynn	24	0.8	18.1	5.6
Bridgeport	25	0.4	13.3	6.4	Quincy	21	0.4	19.8	8.4
Hartford	26	0.3	10.3	5.2	Somerville	25	0.3	19.3	7.7
New Haven	26	0.9	11.8	5.6	Springfield	26	1.1	11.7	5.8
Stamford	26	1.1	11.7	5.0	Mich:				
Del:					Detroit	25	0.7	12.1	4.8
Kent Co*	14	0.3	28.4	6.7	Grand Rapids	21	0.4	9.2	3.7
Wilmington	23	0.8	12.8	4.9	Kalamazoo	25	1.8	17.2	6.7
D.C:					Lansing	25	0.2	12.4	5.4
Washington	23	1.7	14.0	6.3	Saginaw	25	0.3	11.4	5.6
Fla:					Minn:				
Florida Keys*	25	0.5	11.7	5.1	Minneapolis	26	1.8	12.3	5.3
Jacksonville	26	0.4	21.4	6.7	St. Paul	24	1.4	13.8	6.0
Orlando	11	1.5	33.0	9.6	Miss:				
St. Petersburg	23	1.0	21.6	6.7	Jackson	25	0.8	14.2	6.4
Tampa	24	0.6	18.3	7.0	Jackson Co*	19	0.4	15.4	5.5
Ga:					Mo:				
Atlanta	25	0.9	18.2	6.0	Kansas City	23	1.4	18.0	6.7
Columbus	26	1.5	18.0	7.4	Shannon Co*	22	1.7	20.1	9.7
Macon	24	1.7	14.2	5.9	St. Louis	25	1.9	12.4	6.1
Hawaii:					Mont:				
Honolulu	26	0.7	11.1	4.0	Glacier Nat. Pk*	24	0.4	13.6	4.9
Kahaluu	25	1.0	16.8	3.9	Helena	25	2.4	12.0	7.2
Idaho:					Nebr:				
Boise	26	2.3	19.0	7.5	Lincoln	26	0.9	16.7	6.5
Butte Co*	23	2.1	14.4	7.4	Omaha	25	1.9	19.6	7.2
Ill:					Thomas Co*	26	1.6	16.3	7.3
Chicago	26	1.1	12.7	5.7	Nev:				
Cicero	19	1.3	10.4	5.5	Las Vegas	20	2.8	26.0	13.2
Peoria	24	1.7	11.1	6.2	White Pine Co*	22	3.5	21.0	9.0
Springfield	22	1.9	16.3	6.6					

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, ANNUAL SUMMARY, 1962—Con.

[Concentrations in pc/m³]

Station location	Number of Samples	Minimum	Maximum	Average	Station location	Number of Samples	Minimum	Maximum	Average
N.H:					Pittsburgh	26	1.7	12.5	6.1
Coos Co*	22	1.8	10.0	5.7	Reading	24	0.3	12.2	6.2
N.J:					Wilkes-Barre	26	0.4	12.9	5.9
Camden	26	1.8	27.3	7.3	P.R:				
East Orange	23	0.4	11.4	4.8	Loquillo Mountains*	20	0.6	9.9	3.6
Elizabeth	25	1.4	14.6	5.4	San Juan	22	0.6	10.5	4.3
Newark	26	1.5	10.0	5.0	R.I:				
Trenton	22	1.5	20.0	6.5	Providence	26	0.5	10.7	4.9
N.Mex:					Washington Co*	25	0.5	7.8	3.5
Albuquerque	25	1.9	16.0	7.6	S.C:				
Colfax Co*	25	1.4	17.0	7.3	Columbia	22	1.7	13.7	7.8
N.Y:					Greenville	26	1.2	20.0	8.0
Cape Vincent	23	1.7	12.8	6.2	Richland Co*	23	1.0	12.6	5.9
Elmira	13	2.8	17.7	6.5	S.Dak:				
Glen Cove	18	1.1	25.2	6.8	Black Hills Forest*	24	2.1	64.8	9.4
Massena	26	0.7	10.9	4.4	Sioux Falls	22	0.6	11.1	5.5
Mt. Vernon	12	5.1	15.7	8.9	Tenn:				
New Rochelle	11	1.9	11.1	6.6	Chattanooga	25	0.9	11.2	5.1
New York City	25	1.1	13.0	6.4	Memphis	26	0.7	12.8	6.7
Niagara Falls	5	1.5	6.4	3.4	Nashville	26	0.7	20.6	7.3
Rochester	26	0.6	14.1	5.4	Texas:				
Troy	23	1.1	20.4	6.6	Aransas Co*	21	0.7	15.4	6.7
N.C:					Corpus Christi	25	0.8	18.6	6.3
Asheville	25	1.5	18.4	7.1	Dallas	24	0.7	21.0	7.9
Cape Hatteras	23	1.8	29.0	8.5	El Paso	26	0.7	21.0	9.1
Charlotte	24	1.2	12.1	7.0	Ft. Worth	26	0.7	23.0	5.9
Winston-Salem	26	1.0	19.1	7.8	Houston	25	0.4	21.0	5.9
N.Dak:					San Antonio	22	0.5	14.7	4.2
Bismarck	24	1.9	29.8	6.5	Waco	26	0.3	91.0	9.4
Ward Co*	25	2.2	20.1	5.7	Utah:				
Ohio:					Salt Lake City	26	2.6	18.6	8.8
Akron	26	0.7	12.5	5.4	Vt:				
Cincinnati	25	1.9	14.8	5.3	Burlington	21	0.9	11.3	5.4
Cleveland	24	1.4	14.0	6.3	Orange Co*	26	0.5	11.0	5.5
Columbus	25	1.6	20.5	7.1	Va:				
Dayton	25	1.0	13.1	4.6	Danville	26	0.8	14.5	7.5
Lorain	26	1.5	15.5	6.1	Norfolk	24	0.4	14.9	7.0
Springfield	25	1.5	12.5	6.0	Shenandoah Nat. Pk*	26	2.3	12.9	6.9
Toledo	26	0.7	12.3	5.8	Wash:				
Youngstown	26	2.2	12.2	6.2	Clallam Co*	18	0.2	13.1	3.8
Okla:					Seattle	24	0.5	10.5	3.5
Cherokee Co*	25	0.4	15.4	7.2	Tacoma	26	0.1	14.3	4.5
Oklahoma City	23	0.4	13.4	6.8	W.Va:				
Tulsa	23	0.8	24.5	6.1	Charleston	25	0.4	11.2	5.9
Ore:					Huntington	20	0.7	10.7	5.3
Curry Co*	17	0.3	7.2	2.7	Wisc:				
Portland	21	0.8	16.2	5.3	Door Co*	19	0.6	14.0	4.8
Pa:					Milwaukee	22	1.4	18.5	4.7
Clarion Co*	21	0.4	16.1	5.9	Racine	24	1.6	15.0	3.8
Harrisburg	19	0.3	10.6	5.8	Wyo:				
Lancaster	26	0.4	27.0	7.9	Cheyenne	26	1.8	104.6	12.6
Philadelphia	25	0.6	11.9	5.7					

* Nonurban Station.

TABLE 6.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, FOURTH QUARTER 1962

Station		October		November		December	
		pc/liter	nc/m²	pc/liter	nc/m²	pc/liter	nc/m²
Alabama:	Montgomery	—	—	482	61.1	—	—
Florida:	Tampa	—	—	529	22.5	—	—
Louisiana:	Lake Charles	318	21.9	284	31.0	253	24.7
Maine:	Caribou	726	48.6	597	32.8	1,512	57.0
Massachesetts:	Nantucket	342	59.9	233	40.1	1,117	66.1
Michigan:	Sault Ste. Marie	714	36.2	—	—	1,109	51.3
Missouri:	Columbia	326	20.5	—	—	—	—
New York:	Albany	657	58.4	917	36.5	1,544	85.5
North Carolina:	Cape Hatteras	738	42.1	626	194.1	425	79.9
Ohio:	Cincinnati (Airport)	244	14.2	511	24.4	—	—
	Cincinnati (Gest St.)	395	25.7	571	25.9	851	35.8
Pennsylvania:	Philadelphia	—	—	631	65.0	2,203	129.3
South Carolina:	Charleston	146	12.7	772	34.9	—	—
	Greenville	292	25.5	322	32.7	881	70.5
Tennessee:	Nashville	323	16.6	822	60.9	586	23.4
Virginia:	Sterling	—	—	724	87.8	1,055	82.8
Washington:	Tatoosh	571	69.3	702	205.0	715	186.6

Gross Beta Activity in Precipitation

During 1959 a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio and the National Air Sampling Network. Monthly composite samples of precipitation are collected at 29 stations, which are located at Weather Bureau offices or airports. They are then forwarded to the Network laboratory for analysis.

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made.

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM

December 1962

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 6) where the sampling equipment is operated by meteorologists of the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in the Department's reports (*1–2*).

FIGURE 6.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

Air

In the collection of air samples, about 650 cubic meters of air are drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a disk 2 inches in diameter is removed from each filter and counted with a thin-end-window Geiger flow counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to allow for the presence of natural activities and for the decay of short-lived fission products. The result is extrapolated to the end of the sampling period. Canadian air data for December 1962 are given in table 7.

TABLE 7.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, RFSP, DECEMBER 1962

[Average concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Maximum	Minimum	Average
Calgary	13	30.5	3.5	9.8
Coral Harbour	27	90.0	0.6	9.6
Edmonton	31	13.5	3.0	6.8
Ft. Churchill	29	10.0	0.9	5.1
Ft. William	29	26.0	2.0	9.3
Fredericton	31	20.0	1.2	8.9
Goose Bay	30	14.0	1.6	6.1
Inuvik	31	16.0	2.5	7.8
Montreal	31	40.0	2.1	10.4
Moosonee	30	22.0	1.4	8.7
Ottawa	30	49.0	1.0	12.8
Regina	31	22.0	2.5	8.4
Resolute	20	49.0	2.1	8.7
Saskatoon	31	15.0	2.7	8.4
Sault Ste. Marie	11	23.0	3.5	12.8
Shearwater	30	45.0	0.2	12.3
Torbay	31	40.0	0.5	7.8
Toronto	31	19.5	1.4	9.5
Vancouver	31	15.0	0.3	5.2
Whitehorse	31	10.6	1.6	4.7
Windsor	29	33.0	0.6	12.2
Winnipeg	31	47.0	1.7	5.4
Yellowknife	31	17.0	1.6	8.2
Average				8.6

Precipitation

The amount of radioactive fallout being deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample,

TABLE 8.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, DECEMBER 1962

Station	Total beta activity		Deposition of specific radionuclides for selected samples[1,2] (mμc/m²)				
	μμc/liter	mμc/m²	Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}
Calgary	2,940	22.4	2.10	0.15	2.88	0.39	0.84
Coral Harbour	51,800	224					
Edmonton	3,170	67.6					
Ft. Churchill	1,160	27.6					
Ft. William	3,340	85.7					
Fredericton	679	73.9					
Goose Bay	982	35.4					
Inuvik	1,450	49.2					
Montreal	1,580	114	9.65	0.33	22.4	0.53	5.36
Moosonee	859	54.5					
Ottawa	1,930	91.6					
Regina	1,890	22.5					
Resolute	3,440	271					
Saskatoon	1,690	37.8					
Sault Ste. Marie	2,320	98.0					
Shearwater	2,050	257	32.7	1.09	42.3	1.48	16.5
Torbay	1,385	211					
Toronto	1,230	72.6					
Vancouver	2,290	456	51.2	1.58	65.5	2.94	22.0
Whitehorse	1,750	74.4					
Windsor	1,550	60.0					
Winnipeg	1,860	19.8	1.22	0.13	1.37	0.14	—
Yellowknife	2,240	29.0					
Average	4,070	107					

[1] All values corrected for decay back to end of collection month.
[2] Values for strontium-90, cesium-137, and zirconium-95 do not include the activities of their daughter isotopes, yttrium-90, barium-137, and niobium-95.

and sent to the laboratory. December 1962 precipitation data for Canada, including some radiochemical analyses, are shown in table 8.

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(*4*) Beale, J., and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, CNHW (RPD–11)*, (July 1962).

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Recent Coverage in *Radiological Health Data*:

Period	Issue
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*
First quarter 1962	*October 1962*
Second and third quarters 1962	*January 1963*
October 1962	*February 1963*
November 1962	*March 1963*

MEXICAN RADIOACTIVE FALLOUT PROGRAM
December 1962

Radiological Protection Program,
National Commission of Nuclear Energy,
Mexico

The Radiation Surveillance Network of Mexico was established by the "Comisión Nacional de Energía Nuclear" (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation due to fallout from nuclear tests.

Prior to the establishment of the network, two pilot sampling stations were set up in Mexico City and San Luis Potosí to aid in the selection of equipment and sampling sites. Since April 1962 the network has been expanded to twelve stations, ten of which were in operation by the end of December 1962 (see figure 7).

Seven of the ten sampling stations are located at airports and are operated by airline personnel. The remaining three stations are located at Mexico City, Merida, and Veracruz. Staff members of the RPP operate the station at Mexico City, while the other two stations are manned by members of the "Centro de Previsión del Golfo de México."

FIGURE 7.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

Sampling

The sampling procedure involves drawing air 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a 6″ x 8″ high-efficiency glass fiber filter, using high volume samplers. After each 24-hour period the filter is removed and forwarded via airmail to the "Laboratorio de Desechos Radiactivos," CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters. Data are not extrapolated to time of collection.

The maximum, minimum, and average fission product beta concentrations in surface air during December 1962 are presented in table 9.

TABLE 9.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, DECEMBER 1962

[Concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Minimum	Maximum	Average
Acapulco	4	1.3	3.1	2.4
Ciudad Juárez	7	7.1	25.4	16.4
Ensenada	5	3.1	18.5	10.6
Mérida	13	3.3	11.8	8.8
San Luis Potosí	6	2.3	6.8	4.1
Torreón	6	6.0	17.6	11.5
Veracruz	14	0.1	9.3	5.4
Average				8.4

Radioactivity of Surface Air and Fallout, Italy, 1961

Division of Biology and Sanitary Protection
National Committee for Nuclear Energy (Italy)

The Republic of Italy, including the islands of Sardinia and Sicily, compares in latitude with those States ranging from Maine through Virginia in the United States. Comparisons of air and fallout data from the two nations are therefore of some interest.

This review summarizes air and fallout data from selected stations (see figure 1) taken from two semiannual reports (*1*, *2*) of the Comitato Nazionale Per L'Energia Nucleare (CNEN).[a] The selected data originated from 12 cooperating agencies or organizations in addition to CNEN.

Air Sampling

Of the 44 air sampling stations reported by CNEN, 33 were selected for this review because of their uniformity in equipment, materials, and techniques. Continuous daily samples of airborne particulates were collected on 5-cm diameter type SS 589[1] filter paper,[b] with a rate of 100 to 250 m^3/day. The sampler height varied from 1 to 55 meters above ground. Filter gross beta activities were determined 5 days after sampling with end-window G.M. counters calibrated with KCl reference standards. Table 1 presents the monthly average fission product gross beta concentrations in surface air for the 33 selected stations during the calendar year 1961.

[a] National Committee for Nuclear Energy (Italy).
[b] Filter paper SS 589[1] is manufactured by Carl Schleicher and Schuell Co., Germany. It has a fission product retention efficiency of approximately 95 percent.

Fallout Measurements

Monthly fallout samples (including rain) are collected and analyzed by several different methods. The following 3 methods, representing 30 stations were selected for this review (see table 2).

A. Rain gage with ion exchange resin. This device was used at 17 fallout collection stations. The sample is prepared for counting by calcination of the resin.

B. Cylindrical pot with ion exchange resin. Nine stations utilized this device for collection of total fallout. In each case preparation of the

TABLE 1.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR IN ITALY, 1961

[Average concentrations in pc/m^3]

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Alghero	<0.05	<0.05	0.06	0.07	0.08	0.09	0.06	0.06	1.4	5.3	7.1	6.8
Ancona	<0.05	0.06	0.07	0.08	0.08	0.09	0.06	0.05	1.9	5.8	8.3	7.3
Bari	<0.04	0.05	0.07	0.07	0.08	0.10	0.06	0.05	3.2	4.8	8.9	4.9
Bologna	0.06	0.05	0.08	0.09	0.11	0.11	0.10	0.07	1.5	5.4	5.0	7.1
Brindisi	<0.05	0.06	0.06	0.09	0.08	0.08	0.07	0.05	5.6	7.4	12	7.9
Casaccia	0.05	0.08	0.10	0.11	0.12	0.14	0.12	0.14	1.4	5.0	8.3	5.5
Catania									3.9	7.0	11	6.7
Cozzo Spadaro	<0.05	<0.05	<0.05	0.05	0.09	0.09	0.05	0.07	3.8	6.8	14	8.3
Elmas	<0.05	0.06	0.07	0.08	0.09	0.09	0.07	0.06	3.1	5.6	9.1	7.5
Ferrania	0.02	0.04	0.06	0.05	0.06	0.06	0.05	0.06	0.72	4.2	3.2	3.0
Genova	0.05	0.06	0.08	0.08	0.09	0.10	0.06	0.07	0.85	5.4	5.7	6.1
Ispra	0.05	0.04	0.07	0.05	0.07	0.06	0.05	0.05	1.6	6.9	7.5	9.3
Messina	<0.05	0.07	0.08	0.11	0.11	0.10	0.08	0.07	3.4	8.0	14	8.7
Milano "A"	0.10	0.10	0.10	0.07	0.07	0.10	0.05	0.05	1.2	3.4	3.0	3.4
Monte Cimone	<0.05	0.06	0.08	0.07	0.08	0.08	0.06	0.05	1.8	5.3	7.4	7.1
Monte Paganella	<0.05	0.06	0.08	0.06	0.07	0.07	0.06	<0.05	1.1	5.8	8.4	9.6
Monte Sant'Angelo	<0.05	0.06	0.06	0.07	0.06	0.06	0.05	<0.05	1.7	4.0	8.3	5.1
Monte Scuro	<0.05	0.06	0.06	0.06	0.10	0.09	0.07	0.05	2.9	6.2	10	7.0
Monte Terminillo	<0.05	0.06	0.06	0.09	0.09	0.09	0.07	0.05	1.5	5.0	7.8	6.7
Napoli "A"	<0.04	0.05	0.07	0.10	0.10	0.09	0.10	0.08	1.9	5.8	11	6.3
Napoli "B"		0.13	0.14	0.15	0.18	0.12	0.10	0.08	1.7	5.9	10	7.3
Palermo	<0.04	0.06	0.06	0.08	0.10	0.09	0.07	0.06	1.9	5.1	8.7	5.0
Pian Rosa	0.06	0.06	0.10	0.09	0.11	0.11	0.08	0.06	1.2	6.3	11	12
Resina	<0.04	0.05	0.07	0.08	0.08	0.09	0.08	0.06	1.8	5.3	10	5.6
Roma (Capannelle)	0.06	0.06	0.09	0.07	0.06	0.08	0.05	0.07	1.3	4.1	7.6	4.6
Saluggia	0.04	0.05	0.10	0.10	0.09	0.08	0.15	0.07	1.0	4.9	3.6	3.7
San Remo	<0.05	0.06	0.08	0.07	0.08	0.08	0.06	0.06	1.0	6.2	6.5	8.9
Tarvisio	<0.05	<0.05	0.06	0.06	0.06	0.06	0.06	<0.05	1.6	4.5	6.1	6.5
Trapani	<0.05	0.06	0.08	0.06	0.08	0.07	0.05	<0.05	1.0	4.6	9.9	—
Trieste	0.06	0.06	0.07	0.07	0.10	0.09	0.08	0.06	2.0	6.0	7.2	6.3
Verbania Pallanza	0.07	0.07	0.08	0.06	0.09	0.07	0.06	0.05	0.91	4.2	5.0	5.9
Verona Villafranca	<0.05	0.06	0.08	0.07	0.06	0.08	0.06	0.05	1.4	4.9	6.0	6.1
Vigna di Valle	0.06	0.07	0.09	0.11	0.10	0.10	0.08	0.06	1.6	5.4	9.8	6.7

FIGURE 8.—AIR AND FALLOUT SAMPLING LOCATIONS IN ITALY

sample for counting involved incineration of the resins.

C. Cylindical pot. The cylindrical pot with no ion exchange resins was used at 4 of the stations. Preparation in this case was by evaporation.

Radionuclide Analyses of Fallout Samples

In addition to the gross beta radioactivity of fallout samples, the samples collected at Ispra were analyzed for numerous radionuclides. Monthly deposition of these nuclides are given in table 3.

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(*1*) Comitato Nazionale Per L'Energia Nucleare *Data on Environmental Radioactivity Collected in Italy*, BIO/12/61, CNEN (Division of Biology and Health Protection), Via Belisario, 15 Rome (September 1961), Limited Distribution in English French to UNSCEAR.

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TABLE 2.—GROSS BETA ACTIVITY IN MONTHLY FALLOUT (INCLUDING RAIN), ITALY, 1961

[Monthly fallout deposition in nc/m²]

Location	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rain gage with ion-exchange resins												
Brindisi	0.70	0.29	0.20	1.6	0.38	0.20	0.10	0.14	0.18	37	54	51
Cozzo Spadaro	0.40	0.15	0.77	0.09	0.20	0.22	0.07	0.20	0.19	2.1	23	40
Diga di Barcis	0.64	0.16	0.29	3.6	2.3	8.6		5.4	0.83	145	470	26
Elmas	0.77	0.13	0.10	0.23	0.13	0.88	0.13	0.15	2.4	25	85	35
Garigliano	4.7	3.2	2.7	4.9	7.4	4.0	1.4	2.4	5.1	347	1,102	232
Gorgona				0.55	0.60	0.47	0.14	0.39	4.5	45	75	81
Livorno	1.1	0.43	0.75	0.99	1.4	0.54	0.80	0.47	12	32	88	119
Messina	1.1	0.4	0.9	0.5	0.6	0.5	0.10	0.16	0.58	17	74	123
Monte Sant'Angelo	1.2	0.58	0.17	0.85	1.0	0.52	0.81	0.23	0.10	24	29	25
Monte Scuro	1.5	0.25	0.15	2.7	1.2	0.82	0.39	0.32	0.35	28	88	69
Padova	0.60	1.0	0.53	2.3	2.8	2.5	2.1	0.54	1.3	40	145	100
Pantelleria	0.36	0.20	0.31	0.07	0.41	0.89	0.13	0.29	0.64	20	78	59
S. Giusto	1.2	0.37	0.37	1.1	1.7	0.30	0.28	0.47	1.6	30	108	120
S. Piero a Grado	1.2	0.28	0.24	1.3	1.8	0.42	0.28	0.42	9.0	19	160	116
Trapani	1.4	0.19	0.28	0.20	0.22	0.30	0.07	0.21	0.19	16	73	48
Viareggio	0.80	0.26	0.29	0.35	1.1	0.31	0.10	0.52	10	29	111	62
Vigna di Valle	0.60	0.44	0.43	2.1	0.45	0.36	0.19	0.47	1.7	60	110	74
Cylindrical pot with ion-exchange resins												
Bari	0.86	0.27	0.67	0.86	1.1	1.1	0.55	0.23	0.81	37	74	132
Bologna	0.80	0.29	0.18	2.4	1.5	1.0	1.2	0.39	8.7	50	77	120
Genova	0.52	0.33	0.01	2.1	1.0	1.1	0.58	0.42	22	45	116	64
Milano "A"	0.50	1.3	0.11				0.93	0.11	0.69	18	118	36
Napoli "A"	2.1	0.30	0.97	0.56	0.24	0.50	0.92	0.59	1.1	92	172	129
Palermo	1.9		0.6	4.8	1.4	0.5	9.9	1.4	4.2	75	172	189
Resina	1.2	0.48	0.95	2.4	1.7	1.5	0.43	0.44	0.49	59	225	74
Trieste	1.8	0.29	0.86	2.4	1.7	2.2	2.2	0.30	0.73	58	130	74
Verbania Pallanza	0.28	0.53	0.06	3.3	1.7	3.2	1.3	0.32	7.1	162	83	120
Cylindrical pot only												
Casaccia	1.9	0.56	1.1	2.1	1.9	1.5	0.67	0.45	1.1	204	425	152
Ispra	0.55	0.97	0.17	4.7	2.8	4.1	2.1	0.60	13 *	125 *	149 *	36 *
Milano "C"	0.81	1.7	0.29	3.0	1.9	2.9	2.1	0.88	4.6	58	247	76
Napoli "B"			1.7	1.9	3.4	1.0	0.59	0.68	12	41	181	145

* Values corrected for self-absorption and radioactive decay (with reference to the 15th day of the collection month-22nd day in the case of September): September, 36; October, 510; November, 555; December, 110 nc/m².

TABLE 3.—ANALYSES OF VARIOUS RADIONUCLIDES IN THE MONTHLY FALLOUT SAMPLES COLLECTED AT ISPRA, ITALY, 1961

[Monthly deposition in nc/m²]

Radionuclides	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Sr^{90}	0.06	0.08	0.01	0.70	0.35	0.65	0.16	0.05	0.07	0.59	0.42	0.23
Cs^{137}	0.10	0.14	0.02	1.1	0.60	1.1	0.26	0.09	0.10	0.70	0.47	0.25
I^{131}										10	30	
Sr^{89}									1.8	22	29	13
Ba^{140}									7.0	92	78	5
Ce^{141} and Ce^{144}									3.0	48	43	19
Ru^{103} and Ru^{106}									2.0	25	48	11
Zr^{95}–Nb^{95}									2.0	71	102	28

SECTION II.—FOOD

Radionuclides in Institutional Diet Samples
July–September 1962

Division of Radiological Health, Public Health Service

The determination of radionuclide concentration in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is being administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a controlled population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 21 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from exclusive, well-funded boarding schools to orphanages with severe economic limitations. Each institution (sampling point) is located in a community monitored by the Pasteurized Milk Network. The analytical data for this program supplement the findings for the Institutional Diet Sampling Program.

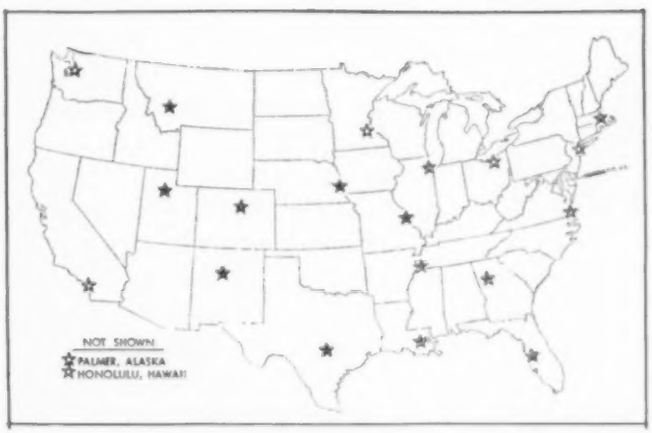

FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS, SEPTEMBER 1962

Sampling Procedure

In general, the sampling procedure is the same in each case. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Meals are frozen following collection. On completion of the total sample, it is packed in dry ice and shipped by air express to either the Southwest-

ern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

Each sample is packaged in three containers: one containing solid food less seed pits, rinds, shells, bones, etc., that would not ordinarily be eaten; one containing dairy products such as milk, cottage cheese, ice cream, etc.; and one containing soft drinks, coffee, tea, etc. A record of the contents of each meal and the approximate weight of each item is recorded by the institution's dietitian and sent with the sample. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

Analytical Program

Total weight, stable calcium, and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Phosphate determinations are made by a colorimetric technique. Because calcium and phosphorus compounds have an effect on the uptake of important boneseeking radionuclides such as strontium–89 and strontium–90 (*2*), they are included in the analytical program.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy, (2) chemical separation of strontium–89 and strontium–90 with subsequent counting, and (3) total radium analysis. In the absence of interferences other than naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan on a per-kilogram basis are: I–131, 10 μμc/kg; Cs–137, 5 μμc/kg; and Ba–140, 10 μμc/kg. Approximate minimum detectable concentrations for Sr–89, Sr–90, and total radium are: 5, 1, and 1 μμc/kg, respectively.

Total radium is determined by ashing, separation, and coprecipitation of radium as sulfate or chromate. After a sample is transferred to planchets and dried, its alpha activity is measured by an internal proportional counter with an appropriate delay for checking ingrowth of radium daughters. Since naturally-occurring radionuclides may contribute to the reported total radium values, the total radium technique is a practical screening indicator only. The bone dose, calculated by assuming total radium to be only radium–226, would therefore be moderately high.

Data Treatment

Table 1 presents the dietary intake data expressed on a per-day basis from July 1962 through September 1962 for the 20 institutions from which samples were received. The reported iodine–131 values are based on the iodine–131 content of the sample at the end of the sample collection period. The true iodine–131 intake may therefore be somewhat greater than the reported values.

Certain of the radioanalyses are reported by the laboratories as being "less than" (<) a specified value. For data averaging, the method employed for presentation in table 1 is that all "less-than" data are assumed to be equal to the full "less-than" values as they appear in the column entitled "monthly maximum averages." The column entitled "monthly minimum averages" reflect the averages in which all "less than" values are considered to be 0.

Strontium–89, strontium–90, iodine–131, cesium–137, and barium–140 averages of the institutions' daily intake, as well as announced

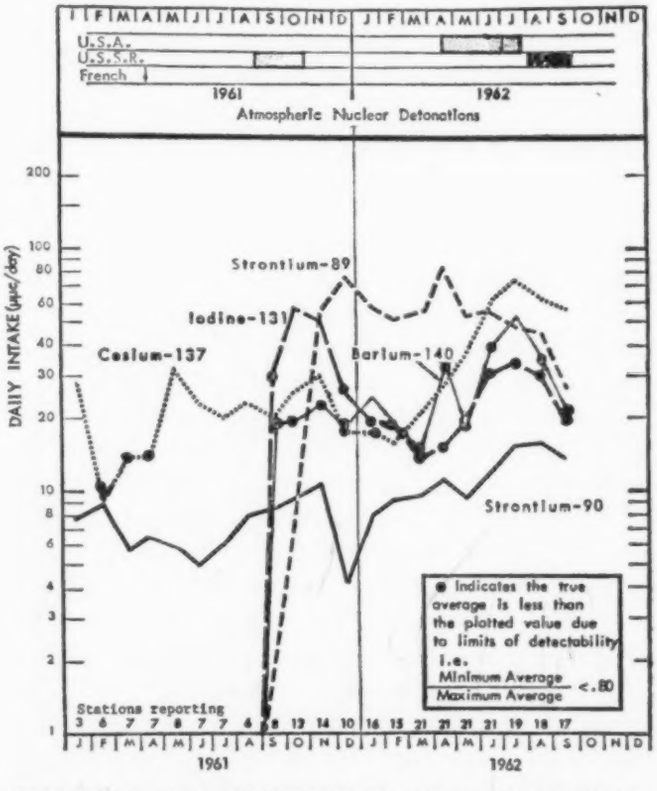

FIGURE 2.—RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

atmospheric nuclear detonations for 1961 and 1962, are shown in figure 2. Figure 3 similarly shows the average daily intake of calcium, phosphate, and potassium and total weight of food.

For rapid comprehension, the data are presented graphically in figures 4–11 as station distributions versus daily intake. These are not graphs of continuous functions as might be implied by their appearance. For example, the graph entitled "total intake" of food is divided into six ranges (< 1.00, 1.00–1.49, 1.50–1.99, 2.00–2.49, 2.50–2.99 and 3.00–3.50 kg/day), and the number of institutions in each range is noted and plotted as a bar graph. The maximum of each bar is connected by a smooth curve. This type of construction is used for each month for each item represented in figures 4–11.

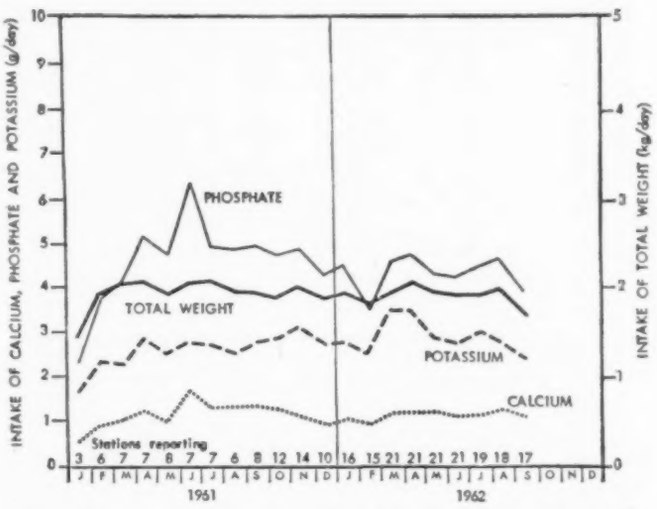
INTAKE OF CALCIUM, PHOSPHATE AND POTASSIUM (g/day)
INTAKE OF TOTAL WEIGHT (kg/day)
PHOSPHATE
TOTAL WEIGHT
POTASSIUM
CALCIUM
Stations reporting
3 6 7 7 8 7 7 6 8 12 14 10 16 15 21 21 21 21 19 18 17
J F M A M J J A S O N D J F M A M J J A S O N D
1961
1962

FIGURE 3.—STABLE MATERIALS IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

Sixteen institutions were used in constructing the graphical distributions and a variation of two institutions or 12.5 percent of the total may not be significant in considering trends in the data.

Discussion of Data

During the 3-month period reported, the dietary intake of strontium–90 ranged between 1 and 42 μμc/day with 39 of 54 institution-months* being in the lowest Radiation Protection Guide (RPG) range. The lowest RPG range established by the Federal Radiation Council is 0 to 20 μμc/day for strontium–90 (*3*, *4*). The May 1962 issue of *Radiological Health Data* contains a discussion of environmental radiation protection standards which should be referred to for an understanding of the RPG (*4*). The strontium–90 distribution (figure 10) has no well-defined peak and is approximately flat between 0 and 25 μμc/day.

The strontium–89 distribution (figure 9) shows that the majority of institutions reported values below 40 μμc/day. The lowest RPG range for strontium–89 is 0 to 200 μμc/day.

The dietary intake of total radium ranged between < 1.0 and 12.0 μμc/day with 93 percent of the institution-months being 6.0 μμc/day or less. Assuming the radium–226 component of the total radium activity to be 30 percent, the intake of radium–226 via the diet probably approaches the top of Range I of the RPG (0 to 2 μμc/day for radium–226) at a few institutions.

Following the resumption of nuclear weapons testing in the atmosphere in 1961, iodine–131 dietary intake increased from nondetectable levels to an institutional high of 228.5 μμc/day (*5*). During the period July–September 1962, the institutional high was 140 μμc/day with only two institution-months being greater than 100 μμc/day. Range II of the iodine–131 RPG is 10–100 μμc/day.

The cesium–137 dietary intake has ranged from < 5 to 225 μμc/day during the period reported. The distribution of institutions (figure 11) does show a peak which extends from 0 to 60 μμc/day. Most institutions have shown a leveling off of the cesium–137 increase that occurred in the second quarter. This can be seen in the average of institutions graph, figure 2.

The distributions of total weight intake of food for this quarter (figure 4) are similar to those for the previous period. The total weight average (figure 3) has usually ranged between about 1.9 and 2.0 kg/day. This average dropped to 1.63 for September 1962, the lowest average noted for the institutional diet sampling program, with the exception of January 1961, when the average of institutions was 1.48.

The calcium intake average of institutions

* An institution-month is one datum value per institution per month. (e.g., 20 institutions reporting one value per month for 3 months constitutes 60 institution months).

TABLE 1.—INSTITUTIONAL DAILY DIETARY

Station	Month (1962)	Alaska, Palmer	Colorado, Denver	Florida, Tampa	Georgia, Atlanta	Hawaii, Honolulu	Illinois, Chicago	Louisiana, New Orleans	Massachusetts, Boston	Minnesota, Minneapolis
Total weight (kg/day)	Jul	1.16	2.29	1.77	1.72	1.97	1.36	2.44	1.94	1.52
	Aug	1.20	2.39	1.58	1.50	1.89	1.58	2.51	2.20	1.82
	Sep	1.22	2.10	1.61	1.42	0.60	1.41	1.83	1.87	1.64
Calcium (g/day)	Jul	0.6	1.4	0.9	0.7	0.8	0.9	1.5	1.0	0.9
	Aug	1.0	1.7	0.8	0.8	0.7	1.4	1.6	1.3	1.0
	Sep	0.8	1.5	0.7	0.8	0.2	0.8	1.2	1.5	1.5
Phosphorus as phosphate [1] (g/day)	Jul	2.4	4.4	3.7	3.6	3.7	4.4	5.8	4.8	3.2
	Aug	2.9	6.1	3.5	3.6	3.4	4.7	5.2	5.6	3.4
	Sep	3.5	4.8	2.7	3.3	1.4	3.4	5.0	4.8	3.8
Potassium (g/day)	Jul	1.8	3.9	1.8	2.1	2.6	4.1	2.9	2.7	2.3
	Aug	1.9	4.1	2.1	1.8	2.3	3.2	4.0	3.7	2.4
	Sep	1.5	3.2	2.3	2.0	0.7	4.9	2.7	2.2	1.8
Total radium ($\mu\mu$c/day)	Jul	2.0	1.0	3.4	1.9	12.0	1.0	<3.0	3.0	<1.0
	Aug	1.0	2.0	2.2	1.6	6.0	2.0	<3.0	2.0	<1.0
	Sep	<1.0	2.0	2.7	<2.0	6.0	2.0	<2.0	5.0	3.0
Strontium-89 ($\mu\mu$c/day)	Jul	10	55	<10	20	30	<5	190	15	45
	Aug	30	45	<10	40	15	15	105	30	40
	Sep	65	45	<10	25	5	10	35	20	60
Strontium-90 ($\mu\mu$c/day)	Jul	5	23	10	16	8	2	35	3	14
	Aug	6	30	14	12	8	9	31	17	19
	Sep	10	25	10	12	2	1	23	11	27
Cesium-137 ($\mu\mu$c/day)	Jul	<5	170	<10	20	60	50	50	210	55
	Aug	20	25	45	50	30	<10	100	90	100
	Sep	45	90	30	50	<5	160	80	50	50
Barium-140 ($\mu\mu$c/day)	Jul	30	90	<20	<20	40	<10	<30	<10	30
	Aug	40	70	<20	<20	40	<10	<30	<10	90
	Sep	<10	40	<20	<20	<10	<10	<20	<10	50
Iodine-131 ($\mu\mu$c/day)	Jul	40	50	<20	<20	60	<10	<30	<10	15
	Aug	40	<10	<20	<20	60	<10	<30	<10	50
	Sep	20	<10	<20	<20	<10	<10	<20	<10	65

[1] The row labeled "Phosphorus" in table 1, pages 472–3 of the December 1962 issue of *Radiological Health Data* is in error. This row should be labeled "Phosphorus as phosphate."

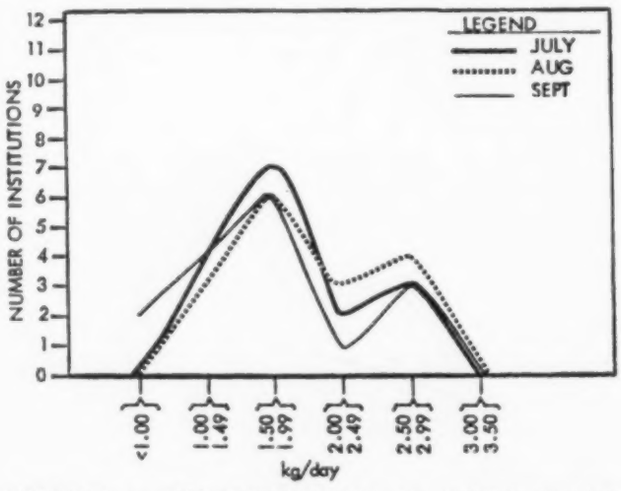

FIGURE 4.—DISTRIBUTIONS OF INSTITUTIONS VERSUS TOTAL DAILY DIETARY INTAKE ON A WEIGHT BASIS

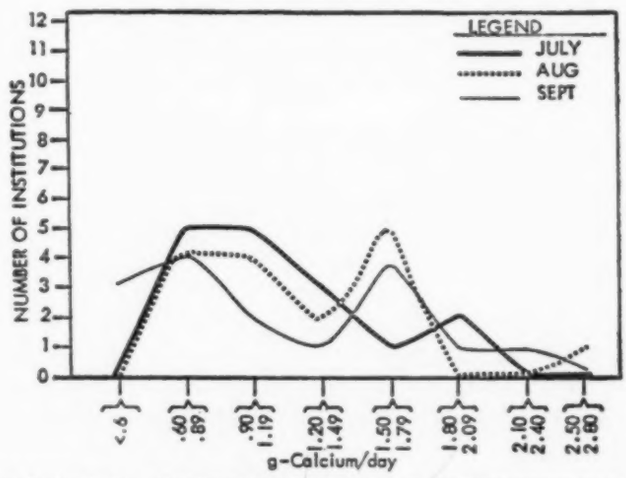

FIGURE 5.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CALCIUM INTAKE

INTAKE (BASED ON A 7-DAY COMPOSITE SAMPLE)

Missouri, St. Louis	Montana, Helena	Nebraska, Omaha	New Mexico, Albuquerque	New York, New York	Ohio, Cleveland	Tennessee, Memphis	Texas, Austin	Utah, Salt Lake City	Virginia, Norfolk	Washington, Seattle	Monthly minimum average	Monthly maximum average
3.02	2.76	1.52	1.69	1.31	1.73	1.27	2.70		1.45	2.90	1.92	1.92
2.62	2.61	1.88	1.69		2.01	1.33	2.84		1.38	2.85	1.99	1.99
	2.55		1.51		1.68	0.81	2.73	1.28	1.02	2.75	1.65	1.65
1.5	1.9	1.1	1.0	0.6	1.2	0.6	1.4		0.6	2.0	1.1	1.1
2.1	1.5	1.3	0.9		1.5	0.9	1.7		0.6	2.5	1.3	1.3
	1.5		0.9		1.1	0.4	2.1	0.8	0.5	1.9	1.1	1.1
7.2	7.2	4.0	4.4	3.5	4.0	2.3	6.0		2.9	8.1	4.5	4.5
6.3	5.3	4.1	3.4		5.0	3.3	6.7		3.1	7.0	4.6	4.6
	5.6		3.0		3.9	1.5	8.2	2.5	3.1	6.3	3.9	3.9
4.8	3.6	2.0	3.4	3.1	5.8	1.4	3.0		1.6	4.9	3.0	3.0
3.7	3.9	2.8	2.7		3.0	1.6	3.1		1.4	4.6	2.8	2.8
	2.0		2.0		2.9	1.2	4.4	1.9	1.4	4.1	2.4	2.4
6.0	6.0	3.0	<1.0	<2.0	<1.0	1.6	2.7		<2.0	9.0	2.8	3.2
1.0	1.0	4.0	2.0		2.0	3.7	1.3		1.5	9.0	2.3	2.5
	<1.0		<1.0		2.0	<1.0	<3.0	<1.0	<1.0	3.0	1.5	2.3
150	110	<10	3	<5	<5	<10	20		135	100	46	49
145	160	70	10		15	20	<15		15	50	45	46
	60		10		5	<5	<15	30	15		26	28
42	17	14	10	6	7	16	17		11	35	15	15
34	34	18	4		6	16	20		9	25	17	17
	22		4		9	6	26	9	12	25	14	14
120	95	25	15	40	225	15	40		20	160	74	75
90	100	75	25		40	25	55		40	215	63	63
	50		30		30	10	55	70	35	110	56	56
150	190	50	80	<10	<10	<20	<30		<20	170	43	52
100	100	20	<10		<10	<20	<30		<20	<10	26	36
	50		30		10	<10	<30	40	<10	<10	13	22
60	<10	120	20	<10	<10	<20	<30		<20	140	27	37
50	100	20	50		<10	<20	30		<20	<10	22	31
	<10		30		10	<10	<30	40	10	<10	10	19

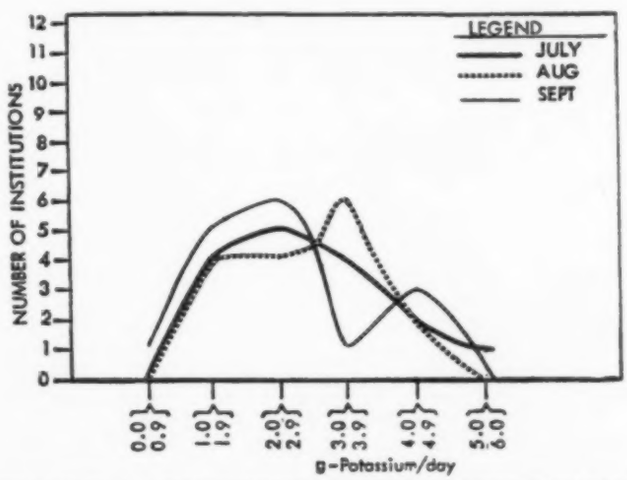

FIGURE 6.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY POTASSIUM INTAKE

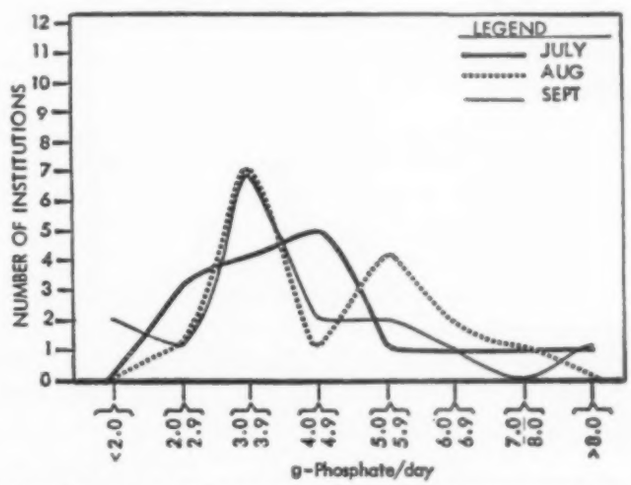

FIGURE 7.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY PHOSPHATE INTAKE

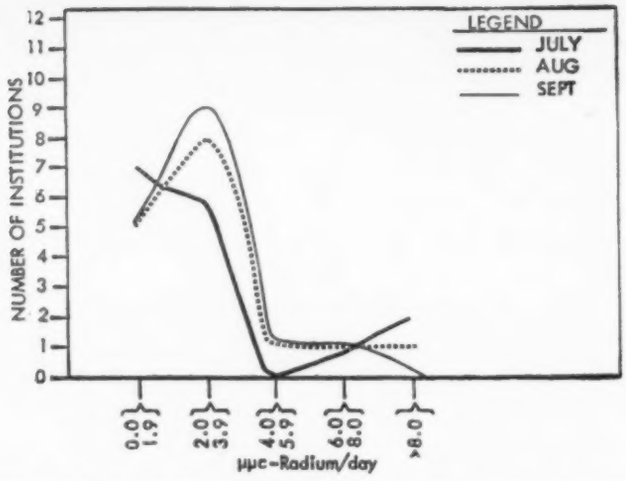

FIGURE 8.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY TOTAL RADIUM INTAKE

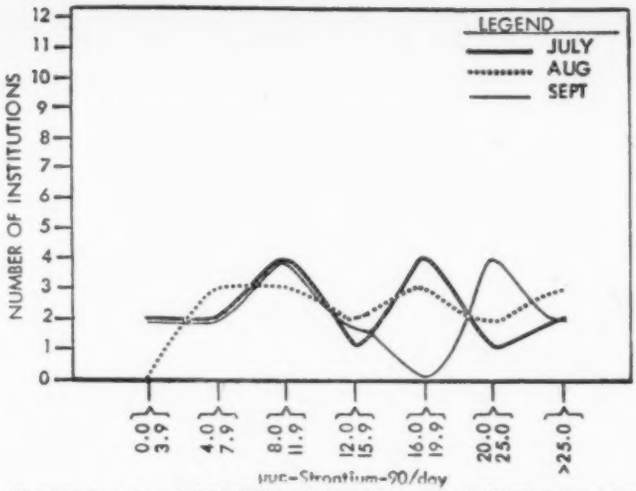

FIGURE 10.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-90 INTAKE

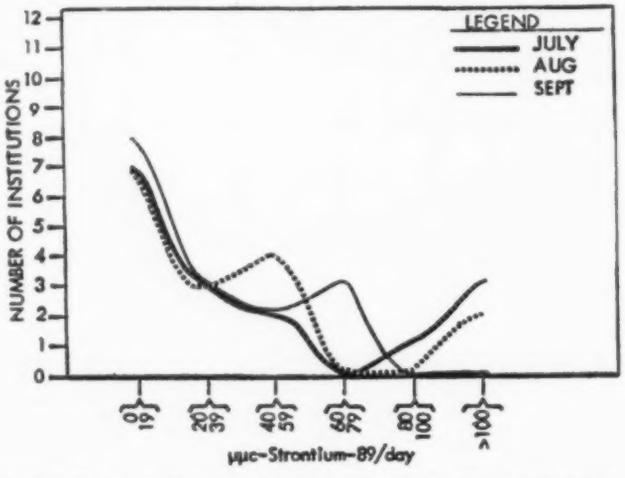

FIGURE 9.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-89 INTAKE

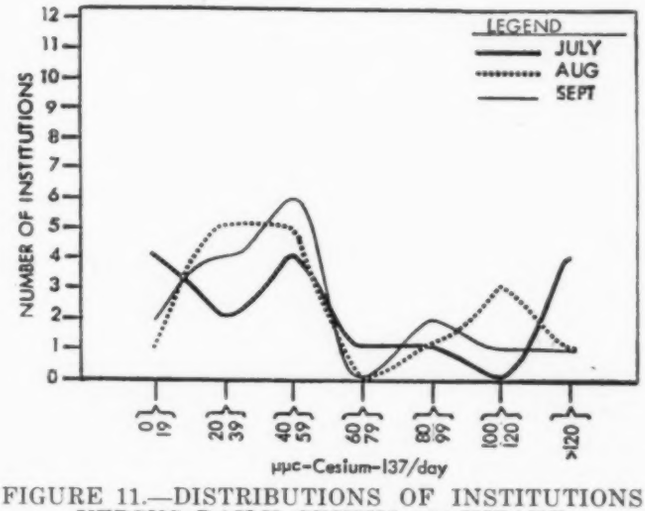

FIGURE 11.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CESIUM-137 INTAKE

(figure 3) has normally ranged between 1.0 and 1.3 g/day while the calcium distribution (figure 5) usually has a well-defined peak. This quarter's results for calcium are not inconsistent with the above statements.

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(3) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards*, Report No. 2, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (September 1961), price 20 cents.

(4) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data, 3*:159–65 (May 1962).

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SECTION III.—MILK

Milk Surveillance

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the U.S. population and contains most of the radionuclides identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

PASTEURIZED MILK NETWORK
December 1962

Division of Radiological Health and
Division of Environmental Engineering
and Food Protection,
Public Health Service

In 1957 the Public Health Service began analyzing raw milk to determine relationships between dairy practices and radionuclide levels in milk. However, it became evident that the milk actually consumed by the population should be included in a broader sampling program. In 1960 the pasteurized milk network was initiated to provide data representative of the milk consumed in selected municipalities. Both raw and pasteurized milk sampling data were reported concurrently until June 1961 to permit comparison of the differences between the earlier, limited, milkshed sampling results and those exhibited in pasteurized milk monitoring. Since June 1961, raw milk sampling has been carried out for investigative rather than monitoring purposes.

During December 1962, pasteurized milk surveillance was conducted at 62 Pasteurized Milk Network stations with the cooperation of State and local milk sanitation agencies which have been shipping samples to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analysis. Publication in *Radiological Health Data* follows 3 to 4 months after sample collection because of the time required for shipment, processing, radioanalysis of strontium, data compilation, and publication procedures. Data from gamma analyses (iodine–131) are available to State public health officials and the Federal Radiation Council within 3 days after sample collection for possible countermeasure purposes.

Sampling and Compositing Procedures

The current program emphasizes (1) measurement of the concentrations of radioactivity in samples of pasteurized milk consumed by the public in various regions of the country, and (2) provision of at least one sampling point within virtually all States; additional points when indicated by widely varying conditions

of the milk supply or when needed in order to cover large population groups. Each sample is a composite of subsamples which are specified to be collected from each plant in proportion to the relative volumes of milk sold. Each of the 62 stations reflects from 80 to 100 percent of the milk consumed in that city with the network average being about 90 percent. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was

TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, DECEMBER 1962

[Average radioactivity concentrations in μμc/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month
Ala:	Montgomery	1.26	1.26	40	60	15	16	40	50	35	45	20	20
Alaska:	Palmer	1.33	1.33	80	40	13	11	110	30	60	60	30	20
Ariz:	Phoenix	1.32	1.30	25	20	5	4	20	20	20	20	<10	<10
Ark:	Little Rock	1.26	1.26	120	180	29	32	110	170	70	95	30	50
Calif:	Sacramento	1.32	1.31	20	20	4	4	20	20	20	20	10	10
	San Francisco	1.34	1.33	20	35	4	5	20	30	20	25	<10	<10
Colo:	Denver	1.34	1.38	20	15	11	11	20	<10	55	60	<10	<10
Conn:	Hartford	1.13	1.11	40	20	11	7	40	10	65	70	10	<10
Del:	Wilmington	1.11	1.11	50	30	15	15	80	40	70	75	20	10
D.C:	Washington	1.20	1.21	40	25	18	17	60	30	55	50	20	10
Fla:	Tampa	1.25	1.26	30	40	10	10	50	50	125	110	10	20
Ga:	Atlanta	1.24	1.25	55	85	17	17	60	90	55	65	20	20
Hawaii:	Honolulu	1.26	1.21	20	30	6	6	20	30	40	40	<10	10
Idaho:	Idaho Falls	1.31	1.30	25	15	13	14	40	20	75	80	10	20
Ill:	Chicago	1.12	1.10	45	30	12	9	70	20	65	70	10	<10
Ind:	Indianapolis	1.17	1.16	50	35	13	10	80	50	55	60	10	<10
Iowa:	Des Moines	1.36	1.33	75	55	14	14	110	80	50	55	20	20
Kans:	Wichita	1.34	1.32	55	45	13	15	70	80	40	45	20	20
Ky:	Louisville	1.23	1.24	95	100	23	20	80	60	45	55	40	40
La:	New Orleans	1.28	1.28	70	95	24	28	70	110	60	75	20	30
Maine:	Portland	1.15	1.18	50	15	17	16	50	10	110	100	20	<10
Md:	Baltimore	1.22	1.20	40	30	17	17	60	30	60	60	20	10
Mass:	Boston	1.13	1.09	60	15	19	17	50	10	110	100	20	<10
Mich:	Detroit	1.13	1.10	50	15	15	11	70	20	75	85	20	<10
	Grand Rapids	1.18	1.12	35	15	12	9	50	20	65	70	10	<10
Minn:	Minneapolis	1.32	1.29	70	25	23	23	70	20	95	95	30	30
Miss:	Jackson	1.30	1.32	90	155	19	24	70	100	45	55	30	40
Mo:	Kansas City	1.33	1.32	100	110	17	19	120	130	45	45	30	30
	St. Louis	1.35	1.33	55	45	14	14	60	30	45	50	20	30
Mont:	Helena	1.35	1.34	45	35	16	16	80	90	85	90	30	20
Nebr:	Omaha	1.37	1.45	60	50	15	16	90	120	55	60	20	10
Nev:	Las Vegas	1.26	1.18	25	25	6	5	10	<10	40	40	<10	<10
N.H:	Manchester	1.16	1.11	50	15	18	15	40	10	115	115	10	<10
N.J:	Trenton	1.12	1.10	45	25	13	8	60	20	65	65	20	<10
N. Mex:	Albuquerque	1.33	1.32	20	30	5	6	30	40	25	25	20	10
N.Y:	Buffalo	1.10	1.11	40	15	13	10	40	10	80	85	10	<10
	New York	1.13	1.13	55	20	17	11	80	20	75	65	20	<10
	Syracuse	1.14	1.12	45	20	14	11	50	10	65	65	10	<10
N.C:	Charlotte	1.27	1.27	50	45	19	21	20	20	50	50	20	20
N.D:	Minot	1.34	1.32	60	25	27	33	60	10	75	85	20	20
Ohio:	Cincinnati	1.16	1.16	60	50	17	14	90	60	45	55	10	10
	Cleveland	1.16	1.15	50	25	14	12	70	40	60	70	<10	<10
Okla:	Oklahoma City	1.21	1.22	65	90	17	19	100	160	40	50	20	30
Ore:	Portland	1.40	1.38	150	145	18	18	60	50	80	80	40	30
Pa:	Philadelphia	1.13	1.11	45	30	14	11	80	30	60	70	10	<10
	Pittsburgh	1.14	1.12	55	40	19	14	110	50	80	85	20	10
P.R:	San Juan	1.17	1.18	75	130	10	13	30	60	45	60	10	20
R.I:	Providence	1.11	1.12	45	15	16	11	60	20	85	85	20	<10
S.C:	Charleston	1.26	1.28	50	80	20	23	40	70	60	65	20	20
S.D:	Rapid City	1.17	1.25	50	35	15	20	70	40	70	85	20	20
Tenn:	Chattanooga	1.28	1.30	95	135	20	24	60	70	50	60	30	50
	Memphis	1.25	1.25	85	110	20	20	80	100	40	45	30	40
Tex:	Austin	1.23	1.25	35	75	8	10	90	200	30	50	20	40
	Dallas	1.23	1.25	90	195	16	19	150	330	45	75	30	60
Utah:	Salt Lake City	1.35	1.33	30	25	11	10	40	20	75	70	30	30
Vt:	Burlington	1.11	1.10	55	20	13	10	60	<10	85	85	20	<10
Va:	Norfolk	1.23	1.23	45	40	20	20	50	40	60	60	20	20
Wash:	Seattle	1.36	1.33	100	55	21	14	60	30	85	75	40	20
	Spokane	1.40	1.38	35	25	15	17	30	20	80	85	10	10
W. Va:	Charleston	1.22	1.21	60	35	21	19	40	20	55	55	20	20
Wis:	Milwaukee	1.18	1.16	45	20	11	8	90	20	70	75	20	<10
Wyo:	Laramie	1.32	1.29	45	40	12	12	20	<10	80	95	10	10
Network average		1.24	1.23	55	50	15.1	14.6	61	51	62	66	19	17

as representative of a community's total supply as could be achieved under practical conditions. Since the resumption of nuclear weapons testing, the sampling frequency has been increased. During December 1962, most stations were sampled twice a week. All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require re-evaluation and adjustment of the sampling frequency and analytical schedule for this program.

Iodine–131, cesium–137, and barium–140 are determined by gamma scintillation spectroscopy,[1] while strontium–89 and strontium–90 are determined by radiochemical procedures. The minimum detectable concentrations in units of μμc/liter are: Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Table 1 presents summaries of all available analyses for December 1962. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

Geographical Variation in Radionuclide Content of Milk (1962)

Iodine–131: Beginning in January 1962 and continuing through February, March, and April, the monthly average iodine–131 concentrations in milk were very low (20 μμc/liter or less) over the entire country. The lowest monthly average values occurred in April. Except in the Southwest, iodine–131 was nondetectable. In May there was a pronounced increase of iodine–131 in milk in Kansas and Missouri. Monthly averages there slightly exceeded the 200 μμc/liter level. Concentrations decreased with distance from the Kansas-Missouri area and dropped to values of 20 μμc/liter or less at the Rocky Mountains, the Appalachian Mountains, the northern part of Texas, and the U.S.–Canadian border. This same focal point was evident in June with approximately the same levels as before noted for milk. Also, a concentration of 350 μμc/liter was observed in eastern Washington in June.

Values for iodine–131 in the Kansas-Missouri area and eastern Washington decreased to below 80 μμc/liter in July. There was however, an iodine–131 concentration of almost 600 μμc/liter noted in Utah in July. August concentrations in milk were below those in July and most of the network stations reported values below 50 μμc/liter. High concentrations in Utah persisted, although the levels decreased to about 300 μμc/liter. September and October concentration contour maps were generally similar. The reported values for the southwestern states were below 20 μμc/liter while various northern States reported concentrations somewhat greater than 100 μμc/liter. In November, a region of iodine–131 concentrations ranging from 100 to 170 μμc/liter extended from Pennsylvania to Oklahoma and from Oklahoma to Wisconsin. Of note in December were average values which reached 300 μμc/liter or slightly greater in eastern Texas (see figure 1). The South and Midwest, as well as an area including Washington, Oregon, Idaho, and Montana, had concentrations of iodine–131 in milk of at least 50 μμc/liter.

In summary, iodine–131 did not appear appreciably in milk until May, and its presence continued throughout the balance of the calendar year. The Southwest usually had low iodine–131 concentrations in milk, however no portion of the country was consistently high. Occasionally, high monthly average concentrations of iodine–131 appeared in various locations.

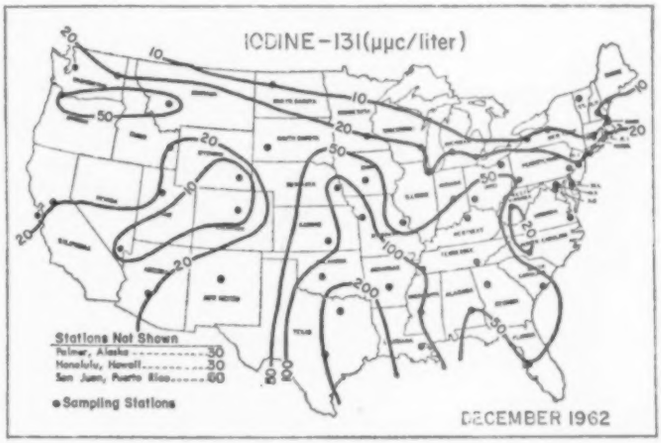

FIGURE 1.—IODINE–131 CONCENTRATIONS IN PASTEURIZED MILK

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

Strontium–89: Stontium–89 monthly average concentrations in milk for January 1962 reached levels of about 300 μμc/liter in Louisiana, but levels decreased rapidly with distance from this area. For the same month, only the Southeast reported concentrations greater than 50 μμc/liter. February and March concentration contour maps appeared remarkably similar in form and level. The epicenter for the 300 μμc/liter concentration for strontium–89 appeared to move northward to the Arkansas-Mississippi-Alabama area in April. The 100 μμc/liter concentration contour centered about this area appeared to expand up the Mississippi Valley during May. Western Washington-Oregon also experienced concentrations of about 100 μμc/liter in May. Concentrations in this area decreased during May. The northern expansion of the 100 μμc/liter contour continued until June when a ridge of strontium–89 concentration of 100 μμc/liter extended from North Dakota to Louisiana. Only the northern portion of this ridge persisted in July. In August, only Wyoming, Nebraska, and Oregon had concentrations somewhat in excess of 100 μμc/liter while in September all of the coterminous U.S. stations reported values lower than 100 μμc/liter. A strontium–89 intrusion of about 100 μμc/liter occurred in the Minnesota-Iowa area and in the Washington-Oregon area in October. During November concentrations of strontium–89 of 100 to 200 μμc/liter appeared in Washington-Oregon, Arkansas, and Kentucky-Tennessee. Strontium–89 in milk in these same areas continued in December. However, two of the highs had merged to form one with concentrations of 100 to 200 μμc/liter covering eastern Texas and the lower Mississippi Valley (see figure 2).

Strontium–90: The monthly average strontium–90 concentrations in milk for January 1962 were generally below 10 μμc/liter. The South and the East had values greater than 10 μμc/liter and the Arkansas-Mississippi-Louisiana area reported values of 20 to 24 μμc/liter. This area of high concentrations continued during February and expanded to include northern Alabama in March. In April, the southeastern States reflected a 20 to 30 μμc/liter concentration pattern for strontium–90. The lower Mississippi Valley reported concentrations up to 40 μμc/liter during this period. Approximately these same conditions existed throughout May and June. An average of 40 μμc/liter appeared in South Dakota in June. The effect of this intrusion was to extend the greater-than-20 μμc/liter concentration area all the length of the Mississippi Valley. In July much the same conditions prevailed as in June. During August, strontium–90 concentrations appeared to decline. Only the Dakotas, the lower Mississippi Valley, and the southern Appalachian States reported values of 20 to 27 μμc/liter. In September, the Dakotas' high had disappeared. October averages of 20 to 29 μμc/liter occurred in the lower Mississippi Valley, along the eastern seaboard, and in the Northwest. Conditions for November were similar to October, except that the high along the eastern seaboard had decreased. The December

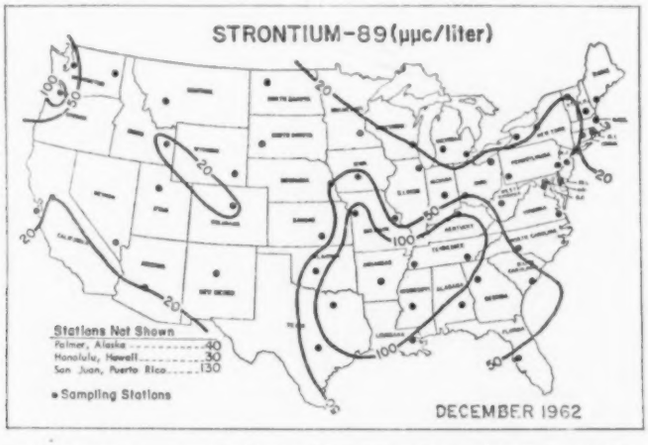

FIGURE 2.—STRONTIUM–89 CONCENTRATIONS IN PASTEURIZED MILK

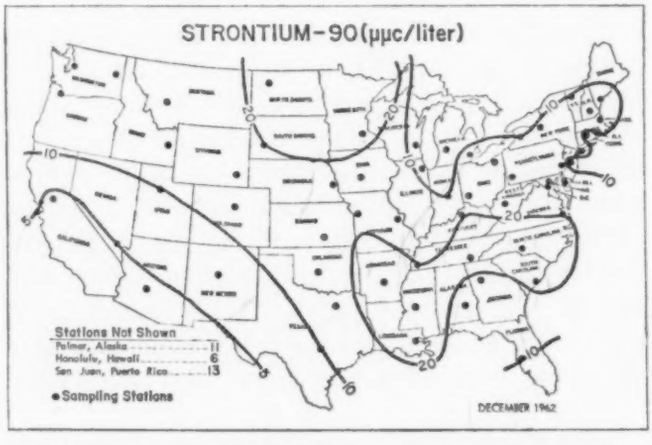

FIGURE 3.—STRONTIUM–90 CONCENTRATIONS IN PASTEURIZED MILK

monthly averages of strontium–90 concentrations in milk are presented in figure 3. Monthly averages of 20 to 33 μμc/liter were reported for Minnesota, the Dakotas, and most of the Southern States.

In summary, most of the stations reported values of strontium–90 in milk of between 10 and 20 μμc/liter throughout the entire year. The Southwest was consistently low (< 10 μμc/liter) while the lower Mississippi Valley consistently displayed higher values (20 to 40 μμc/liter). The Southeastern and the Great Plains States sporadically showed values of 20 to 40 μμc/liter.

Selected Monthly Strontium–90 Profiles

In previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from selected cities in the monitoring program were published. Profiles for an additional 16 cities are presented in figure 4. These graphs show the strontium–90 concentrations in milk from selected cities in the 4 major Bureau of the Census regions.

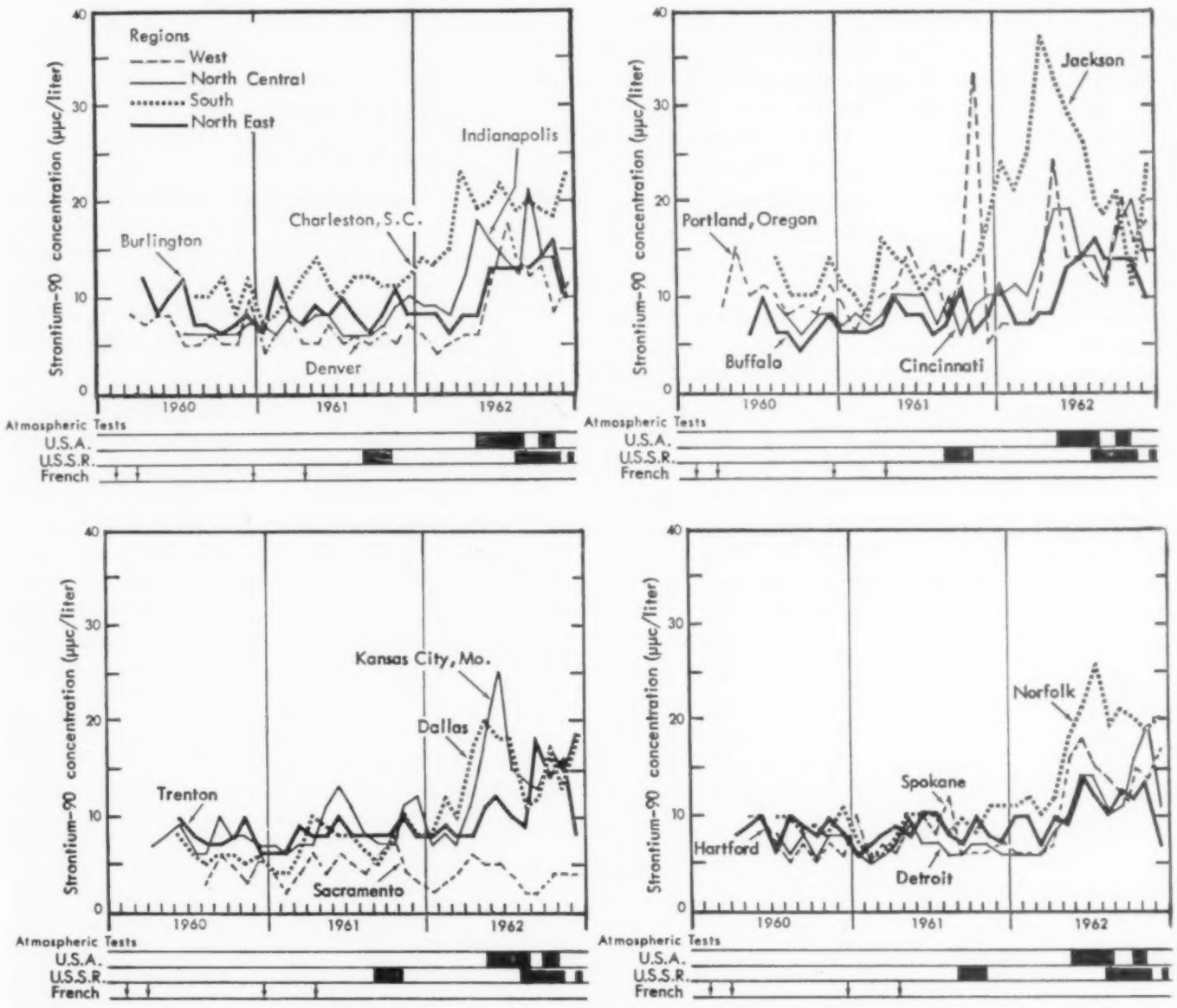

FIGURE 4.—STRONTIUM–90 CONCENTRATIONS IN PASTEURIZED MILK

INDIANA MILK NETWORK
December 1962–January 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analyses in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 5).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium-lanthanum–140, strontium–89, and strontium–90. Analyses for the gamma emitters iodine–131, cesium–137, and barium-lanthanum–140 are conducted on a weekly basis except when iodine–131 results exceed 100 μμc/liter, at which time the frequency of sampling is increased. Strontium–89 and strontium–90 analyses are performed monthly on samples which are composited from weekly aliquots.

The ion exchange analytical procedure (*1*) is used for strontium–89 and strontium–90 analyses. A 512-channel pulse-height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium-lanthanum–140.

FIGURE 5.—INDIANA MILK SAMPLING LOCATIONS

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 2. The State average is an arithmetic average of the station values.

REFERENCE

(*1*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium–90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33*:1306–8 (September 1961).

TABLE 2.—RADIONUCLIDES IN INDIANA MILK, DECEMBER 1962–JANUARY 1963

[Concentrations in μμc/liter]

Sampling location	Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-Lanthanum-140	
	December	January	December	January	December	January	December	January	December	January
Evansville	20	20	22	17	20	<10	45	50	<10	<10
Fort Wayne	30	—	16	18	10	<10	45	50	<10	<10
Indianapolis	50	<10	22	23	30	<10	50	55	<10	<10
Rochester	15	<10	18	22	20	<10	50	55	<10	<10
Seymour	20	<10	20	24	30	<10	50	50	10	<10
State average	25	10	20	21	20	<10	50	50	<10	<10

MINNESOTA MILK NETWORK
March–September 1962

Division of Environmental Sanitation
Minnesota Department of Health

The Minnesota State Department of Health initiated a pasteurized milk surveillance network in September 1958 to monitor milk for strontium–90. Since then the network has been expanded to eleven sampling locations (see figure 6). In October 1961 a special network of eight stations (see figure 6) was established for the collection of milk "grab" samples for iodine–131 analyses.

Each station daily collects a two-ounce sample and produces a monthly composite sample to be analyzed for strontium–90. Collection is made at the pasteurizing plants' bottling machines so that the sample is randomly representative of the milk produced in that milkshed. The most recent strontium–90 data is shown in table 3.

One-liter samples are collected weekly for iodine–131 analyses. These monthly averages are shown in table 4. The minimum detectable concentration of iodine–131 in milk is 15 μμc/liter. The monthly average is an arithmetic average of all samples collected within a given month. A value of 7 μμc/liter is used when averaging values which are reported as < 15 μμc/liter. If the calculated monthly average is below 15 μμc/liter, then the monthly average is reported as < 15 μμc/liter. All other monthly averages have been rounded to the nearest 10 μμc/liter.

Analytical Procedure

Strontium–90 in milk is determined by ashing an 800 ml sample, after evaporation at 450° C. Calcium and strontium are precipitated as oxalates from the ash. The separated oxalates are destroyed and the resulting solution scavenged with yttrium and barium. Yttrium–90 is allowed to ingrow and is then precipitated. This precipitate is converted to the oxalate, filtered and counted in a low-background anticoincidence counter.

Iodine–131 is determined by gamma spectrometry. One-liter samples of milk are counted for 100 minutes with a low-background sodium iodide crystal scintillator and multichannel analyzer. The counts in the iodine–131 photopeak (0.36 Mev) which occur because of background and scatter from other gamma-emitting nuclides in milk are determined empirically and subtracted from the total count.

FIGURE 6.—MINNESOTA MILK SAMPLING LOCATIONS

TABLE 3.—STRONTIUM-90 IN MINNESOTA MILK, MARCH–SEPTEMBER 1962

[Concentrations in μμc/liter]

Sampling location	March	April	May	June	July	August	September
Bemidji	[a]—	—	16.7	34.0	34.6	36.9	21.8
Brainerd	9.6	9.1	—	—	—	—	—
Duluth	—	7.7	14.8	38.0	35.4	15.4	26.9
Fairmont	2.5	4.1	—	—	—	—	—
Fergus Falls	—	—	18.1	26.0	25.5	21.8	21.9
Little Falls	—	—	33.0	27.0	38.0	29.9	26.4
Mankato	—	—	6.3	16.0	11.8	29.2	12.2
Minneapolis	4.3	4.2	10.9	20.0	21.8	21.1	17.7
Rochester	—	5.6	9.7	14.0	18.7	12.0	12.7
Thief River Falls	3.2	4.0	—	—	—	—	—
Worthington	—	—	8.8	—	20.1	15.0	16.4

[a] A dash indicates no sample.

TABLE 4.—AVERAGE IODINE-131 IN MINNESOTA MILK, MARCH–AUGUST 1962

[Concentrations in μμc/liter]

Sampling location	March	April	May	June	July	August
Bemidji	[a]—	—	50	20	40	30
Duluth	<15	<15	30	20	20	30
Fergus Falls	—	—	110	20	50	20
Little Falls	—	—	60	40	40	40
Mankato	—	—	60	40	40	30
Minneapolis	—	—	70	40	20	20
Rochester	—	—	60	30	<15	50
Worthington	<15	<15	250	70	40	30

[a] A dash indicates no sample.

Recent coverage in *Radiological Health Data*:

Period	Issue
October–December 1961 (iodine–131 data)	*March 1962*
May–December 1961 (strontium–90 data)	*August 1962*

NEW YORK MILK NETWORK
October–November 1962

Division of Special Health Services
State of New York Department of Health

Pasteurized milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 7), are analyzed for radionuclide content by the State of New York Department of Health. Weekly composites of daily samples are analyzed for strontium–89, strontium–90 and iodine–131. The milk samples are collected daily from processing plants in all cities except Albany, where collection is made at a market.

At Albany and New York City daily iodine–131 analyses have been made. In the event that a city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken. The matrix method (*1*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum were separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods to concentrate the strontium, elution

FIGURE 7.—NEW YORK MILK SAMPLING LOCATIONS

TABLE 5.—RADIONUCLIDES IN NEW YORK MILK, OCTOBER–NOVEMBER 1962

[Concentrations in pc/liter]

Sampling location	Strontium-89		Strontium-90		Iodine-131		Cesium-137	
	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.
Albany	50	30	11	11	40	25	55	65
	[a](4)	(4)	(4)	(4)	(26)	(25)	(22)	(25)
Buffalo	42	30	9	11	45	<20	50	62
	(6)	(4)	(6)	(4)	(5)	(6)	(5)	(6)
Massena	100	35	20	12	65	<20	90	117
	(4)	(4)	(4)	(4)	(7)	(4)	(8)	(4)
Newburgh	100	51	7	10	45	43	55	77
	(3)	(4)	(3)	(4)	(7)	(3)	(7)	(5)
New York City	80	46	19	9	75	55	[b]—	—
	(3)	(5)	(3)	(5)	(17)	(14)		
Syracuse	45	21	11	7	65	<20	31	44
	(3)	(3)	(3)	(3)	(6)	(3)	(5)	(5)

[a] Numbers in parentheses indicate the number of samples upon which the monthly average is based.

[b] A dash indicates no sample.

of strontium isotopes from the ion exchange resin with sodium chloride, gathering by means of sodium carbonate, isolation by means of ethylenediaminetetraacetic acid, (EDTA) and counting of radiostrontium with a low-background beta counter having a 0.8 mg/cm^2 window. The strontium–90 is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product, yttrium–90.

Table 5 shows the monthly radionuclide concentration averages for October and November 1962. The numbers in parentheses below the data values are the number of determinations used to compute the monthly average.

REFERENCE

(*1*) Hagee, G. R. et al.: Determination of Iodine–131, Cesium–137, and Barium–140 in Fluid Milk By Gamma Spectroscopy, *Talanta 5*:36 (1960).

RADIOSTRONTIUM IN MILK (*1*)
July–September 1962

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory (HASL) began monitoring liquid whole milk in New York City in 1954 for strontium–90 in order to estimate the dietary contribution from the ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York, and at Mandan, North Dakota. Liquid whole milk monitoring was started in Honolulu, Hawaii in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu sample is a monthly composite of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used for cattle feed, while the Perry sample is powdered whole milk used for human consumption. The Honolulu data are of interest since the cows there are on pasture throughout the year and soil analyses have shown strontium–90 concentrations in soils in Hawaii to be comparable with those in the New York area (*2*).

Strontium–89 became measurable in September 1961, indicating that fresh fission products from the U.S.S.R. nuclear test series were being deposited. The Sr^{89}/Sr^{90} ratios are presented in tables 6 and 7, as are the calcium and strontium data. The fluctuations of strontium–90 with time are shown in figures 8 and 9.

Comment

The Honolulu milk samples still contain less strontium–90 per liter than those of other sampling stations. The 1961 average showed a downward trend in μμc Sr^{90}/g Ca at each station. However, since the first quarter 1962 levels have risen at all stations and, during the spring and summer of 1962, reached levels comparable to those observed in 1959.

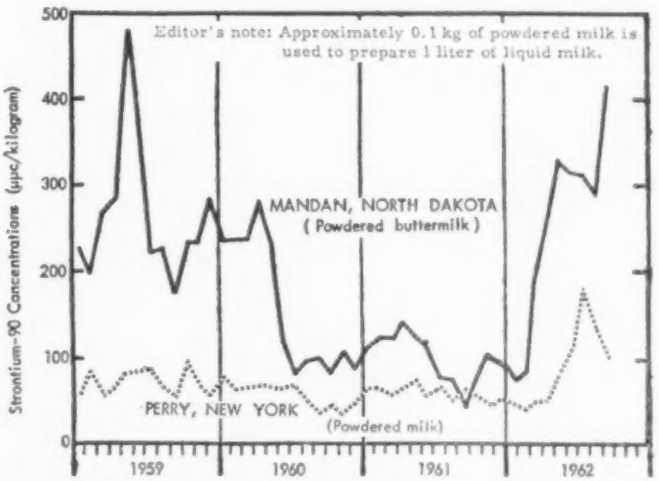

FIGURE 8.—STRONTIUM–90 IN POWDERED MILK SAMPLES

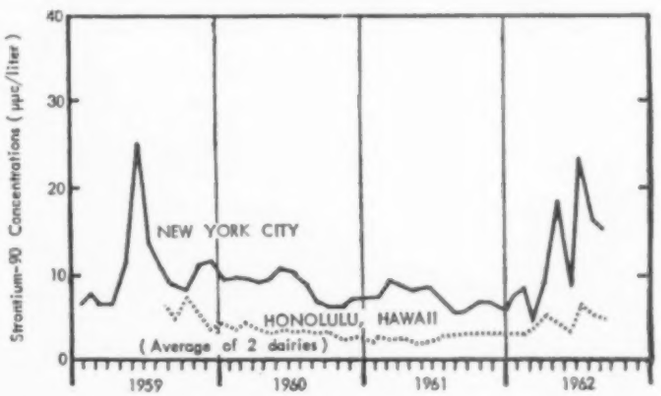

FIGURE 9.—STRONTIUM–90 IN LIQUID MILK SAMPLES

TABLE 6.—RADIOSTRONTIUM AND CALCIUM IN LIQUID MILK, FIRST THREE QUARTERS, 1962

Sampling station and period	Calcium (g/liter)	Strontium-90 (μμc/liter)	Strontium-90 (μμc/g Ca)	Sr^{89}/Sr^{90}*
New York City				
1959 Average			11	
1960 Average			8.0	
1961 Average			6.7	
1962 First quarter			5.3	
Second quarter			10.9	
July	1.02	23.7	23.3	4
August	0.93	16.2	17.4	3
September	0.99	15.1	15.3	6
Honolulu, Hawaii				
1959 Average			5.0	
1960 Average			3.2	
1961 Average			2.4	
1962 First quarter			2.8	
Second quarter			4.1	
July	1.05	6.3	6.0	3
August	1.13	5.4	4.8	3
September	1.11	4.7	4.3	2

* Strontium-89 value extrapolated to the midpoint of sampling period.

TABLE 7.—RADIOSTRONTIUM AND CALCIUM IN POWDERED MILK AND BUTTERMILK, FIRST THREE QUARTERS, 1962

Sampling station and period	Calcium (g/kg)	Strontium-90 (μμc/kg)	Strontium-90 (μμc/g Ca)	Sr^{89}/Sr^{90}*
Powdered milk				
Perry, New York				
1959 Average			8.0	
1960 Average			6.5	
1961 Average			6.2	
1962 First quarter			5.3	
Second quarter			9.1	
July	8.4	182	21.7	3
August	8.7	136	15.6	3
September	7.5	106	14.2	2
Powdered buttermilk				
Mandan, North Dakota				
1959 Average			25.7	
1960 Average			15.0	
1961 Average			9.4	
1962 First quarter			10.5	
Second quarter			26.0	
July	9.3	312	33.6	4
August	10.8	289	26.8	5
September	11.7	420	35.9	5

* Strontium-89 value extrapolated to the midpoint of sampling period.

Previous coverage in *Radiological Health Data*:

Period	Issue
December 1960–April 1961	*December 1961*
May–July 1961	*March 1962*
August–December 1961	*June 1962*
January–February 1962	*September 1962*
March–June 1962	*January 1963*

REFERENCES

(*1*) U.S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL–132*, Office of Technical Services, Department of Commerce, Washington 25, D.C. (January 1, 1963), price $3.50.

(*2*) U.S. Atomic Energy Commission: *Summary of Available Data on the Strontium–90 Content of Foods and of Total Diets in the United States, HASL–90*:4, Office of Technical Services, Department of Commerce, Washington 25, D.C. (August 18, 1960).

CANADIAN MILK NETWORK
November 1962

Radiation Protection Division
Department of National Health and Welfare, Ottawa, Canada

Dried Milk Products

Beginning in November 1955, radiochemical analyses of skim milk and buttermilk powders for strontium–90 concentrations were initiated by the Department of National Health and Welfare. Since April 1962, analyses for strontium–89 and cesium–137 have also been included.

Samples are collected through the cooperation of the Dairy Products Division of the Canadian Department of Agriculture, whose inspectors pick up four 1-pound samples of dried milk from each station (see figure 10) on a monthly schedule.

FIGURE 10.—CANADIAN MILK SAMPLING STATIONS

No statistical plan is followed for sample collection. Because of uncertainties introduced by this method of sampling, the significance of differences between station-to-station and month-to-month results is not precisely known. However, it is possible to consider all results for a given period of time as being sufficiently random in selection to show any national trend when average values for such periods and all stations are plotted, as in figures 11 and 12.

A detailed discussion of the sampling and radiochemical procedures employed may be found in the Department's publications (*1*, *2*). Table 8 presents the results of measurements

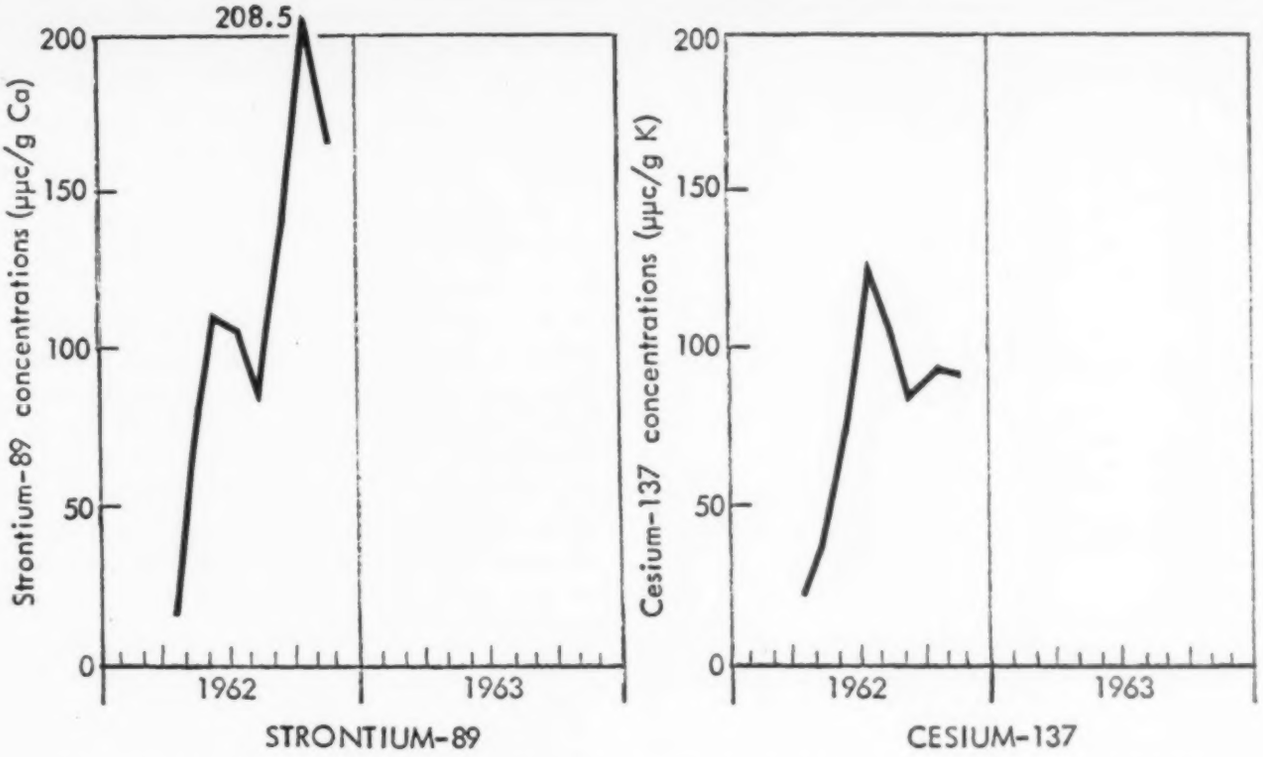

FIGURE 11.—AVERAGE CONCENTRATIONS IN CANADIAN DRIED MILK POWDER

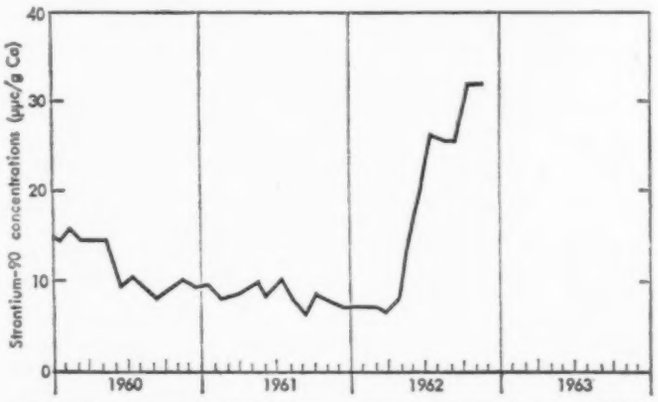

FIGURE 12.—AVERAGE STRONTIUM-90 CONCENTRATIONS IN CANADIAN DRIED MILK POWDER

of strontium–89, strontium–90, and cesium–137 in Canadian dried milk powder for November 1962. These data were taken from the "Data from Radiation Protection Programs," dated January 1963, published by the Radiation Protection Division of the Department of National Health and Welfare.

For an approximate method to compare the Canadian powdered milk data in units of μμc/g calcium to other milk data in units of μμc/liter, it can be assumed that milk has approximately 1.2 g calcium/liter of liquid milk. Canadian

TABLE 8.—RADIONUCLIDES IN CANADIAN DRIED MILK POWDER, NOVEMBER 1962

Station	Strontium-89 (μμc/g Ca)	Strontium-90 (μμc/g Ca)	Cesium-137 (μμc/g K)
Arborg	85.5	24.6	86
Calgary	197.2	39.9	94
E. Florenceville	[a]—	—	—
Edmonton	124.4	30.1	87
Grunthal	64.5	23.8	69
Halifax	192.6	50.3	133
La Durantaye	43.2	30.8	98
Lawrenceville	209.9	34.3	131
London	136.2	18.1	66
Megantic	—	—	—
Moncton	156.8	47.3	124
Nicolet	187.6	25.1	70
Ottawa	150.8	19.2	67
Saskatoon	132.8	29.4	33
Sussex	282.5	63.6	124
Vancouver	392.5	38.8	118
Walkerton	91.0	15.7	55
Average	163.2	32.7	90.3

[a] Dash indicates no sample.

powdered milk data may be compared to liquid milk data by multiplying the former values by 1.2.

Whole Milk

Recently, monitoring of liquid whole milk for iodine–131 was begun. Table 9 presents the November and December average concentration of iodine–131 in liquid whole milk for nine cities. It may be noted that the average, which

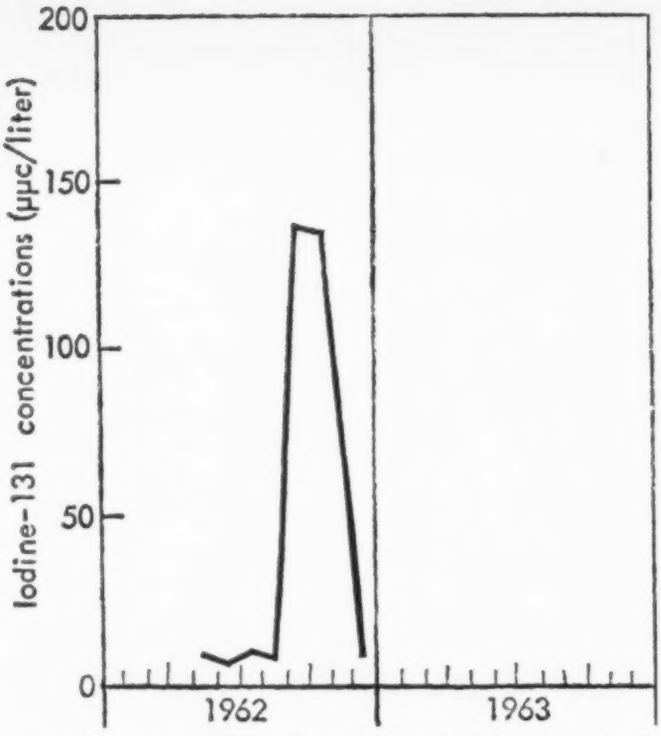

FIGURE 13.—AVERAGE IODINE-131 CONCENTRATIONS IN CANADIAN WHOLE MILK

TABLE 9.—IODINE-131 IN CANADIAN LIQUID WHOLE MILK, 1962

[Concentrations in μμc/liter]

Station	November	December
Calgary	114 (13)[a]	9 (12)
Halifax	38 (13)	10 (10)
London	51 (13)	—
Ottawa	15 (12)	5 (10)
Quebec	31 (13)	7 (11)
Saskatoon	84 (13)	4 (10)
Sault Ste. Marie	24 (12)	8 (11)
Vancouver	86 (12)	8 (10)
Windsor	—	12 (7)
Winnipeg	14 (13)	3 (12)
Average	51	7

[a] Numbers in parentheses indicate the number of samples on which the monthly average is based.

increased to about 135 μμc/liter during September and October, has decreased to 51 μμc/liter for November (see figure 13). In December the average further fell to 7 μμc/liter, indicating very little fresh fallout entering the milk.

It should be emphasized again that the interpretation of fallout data in relation to health is a complex problem. In comparing the values of the concentration levels in a particular medium with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*3*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period, such as one year, represent a better basis for comparison than do individual levels at any specific time.

Previous coverage in *Radiological Health Data*:

Period	Issue
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*
First quarter 1962	*October 1962*
Second quarter 1962	*January 1963*
Third quarter 1962	*February 1963*
October 1962	*March 1963*

REFERENCES

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, CNHW (RPD–1)* (July 1958).

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(*3*) Recommendations of the International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

MEXICAN MILK NETWORK

March–October 1962

Radiological Protection Program

National Commission of Nuclear Energy,

Mexico

The Pasteurized Milk Monitoring Program of Mexico was established by the "Comisíon Nacional de Energía Nuclear" through its Radiological Protection Program in March 1962 to provide a means for estimating the ingestion of strontium–90 from milk.

Milk has been analyzed from twelve cities distributed throughout Mexico (see figure 14). Since each city is supplied from a large number of sources, it has not been possible, until now, to apply a representative sampling method. However, at least four samples from the main sources that supply large population groups were collected in each city.

The results presented in table 10 give a rough estimation of the strontium–90 content of the milk consumed in Mexico. These results are low compared to the PHS milk network average of 14.4 μμc/liter for the third quarter 1962 but are comparable with those in Hawaii for the same period.

FIGURE 14.—MEXICAN PASTEURIZED MILK SAMPLING STATIONS

TABLE 10.—STRONTIUM-90 IN MEXICAN PASTEURIZED MILK, MARCH–OCTOBER 1962

[Monthly Averages]

Month (1962)	Sampling location	Calcium (g/liter)	Strontium-90 (μμc/liter)	Strontium-90 (μμc/g Ca)
March	México, D. F.[a]	—	1.0	—
April	México, D. F.	—	1.7	—
	Veracruz	—	20.0	—
May	México, D. F.	—	2.5	—
	Oaxaca	—	2.7	—
June	México, D. F.	1.0	1.4	1.4
	Guanajuato	1.0	2.1	2.1
July	México, D. F.	1.4	1.6	1.1
	Mariscala	1.0	1.0	1.0
	Chalco	1.0	2.4	2.5
	Colima	1.0	1.0	1.0
August	México, D. F.	1.0	2.3	2.3
	Manzanillo	1.2	2.0	1.8
	Celaya	1.1	2.8	2.6
	Irapuato	1.0	1.0	1.0
	Colima	1.0	1.0	1.0
September	México, D. F.	1.1	1.0	1.0
	Mérida	0.9	3.2	3.6
October	México, D. F.	1.1	2.5	2.3
	Tuxpam	1.2	1.5	1.3

[a] Mexico City.

Twelve-Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine–131: February 1962–January 1963
Strontium–89 and strontium–90: January 1962–December 1962
Division of Radiological Health, Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in micromicrocuries per day. The action ranges as proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1*, *2*, *3*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 below furnish a means towards estimating the contribution of milk to the total dietary intake of iodine–131, strontium–89, and strontium–90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the nuclides. They present index values which are the estimated sum of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium–89 and strontium–90 analysis, these 12-month index values are for the year beginning one month earlier than the iodine–131 values. The columns of monthly index values in each table are used to compute the net change as the yearly index values are advanced by one month. The following column shows this new 12-month index value. In addition, the first column in table 1 gives the iodine–131 January 1963 concentration averages.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged and an average for the month is obtained, and (c) the monthly radionuclide index value is determined by multiplying the average for the month by the number of days in the month. The number of days in the month will be either 28 or 35, corresponding to the complete calendar weeks used for any month. Procedures exemplified by (a) and (b) above minimize the effect of any one day's sample results on the average for the month, particularly for a short-lived radionuclide such as iodine–131. The moving index value is obtained by the following procedure. In column (A) are the twelve-month index values for the period indicated. In columns (B) and (C) are the monthly index values for the period indicated. The values in column (D) are obtained by adding the values in column (B) to those in column (A) and subtracting those in (C).

For a number of reasons it is desirable to have a standard quantity of milk to use in the development of index values for the different radionuclides. When one is concerned with strontium, 1 liter is a suitable quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. When one is concerned with iodine–131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6–18 month group is not more than 1 liter per day. Thus the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

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(*1*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office (September 1961), price 20 cents.

(*2*) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data*, *3*:159–65, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (May 1962).

(*3*) Public Health Service: Special Report, *Radiological Health Data*, *3*:ii–iii, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (September 1962).

TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

Sampling locations		Jan. 1963 iodine-131 averages ($\mu\mu$c/liter)	Iodine-131 index values ($\mu\mu$c day/liter) [a]			
			Jan. 1962–Dec. 1962 (A)	Jan. 1962 (B)	Dec. 30, 1962–Jan. 26, 1963 (C)	Feb. 1962–Jan. 1963 (D)
Ala:	Montgomery	10	6,450	140	280	6,590
Alaska:	Palmer	20	37,800	140	560	38,220
Ariz:	Phoenix	10	4,260	270	280	4,270
Ark:	Little Rock	40	13,270	140	1,120	14,250
Calif:	Sacramento	30	4,350	140	840	5,050
	San Francisco	20	4,920	540	560	4,940
Colo:	Denver	20	5,570	270	560	5,860
Conn:	Hartford	<10	7,670	140	140	7,670
Del:	Wilmington	<10	11,730	140	140	11,730
D.C:	Washington	<10	8,440	140	140	8,440
Fla:	Tampa	20	5,820	140	560	6,240
Ga:	Atlanta	20	8,480	140	560	8,900
Hawaii	Honolulu	20	4,410	140	560	4,830
Idaho:	Idaho Falls	20	9,240	140	560	9,660
Ill:	Chicago	<10	13,690	140	140	13,690
Ind:	Indianapolis	10	11,870	140	280	12,010
Iowa:	Des Moines	20	21,550	270	560	21,840
Kans:	Wichita	20	21,450	270	560	21,740
Ky:	Louisville	<10	10,540	140	140	10,540
La:	New Orleans	20	8,480	140	560	8,900
Maine:	Portland	10	8,020	140	280	8,160
Md:	Baltimore	<10	8,690	140	140	8,690
Mass:	Boston	<10	7,950	140	140	7,950
Mich:	Detroit	10	12,680	140	280	12,820
	Grand Rapids	10	9,280	140	280	9,420
Minn:	Minneapolis	20	15,750	140	560	16,170
Miss:	Jackson	30	8,410	140	840	9,110
Mo:	Kansas City	10	30,370	270	280	30,380
	St. Louis	20	12,110	140	560	12,530
Mont:	Helena	20	14,490	140	560	14,910
Nebr:	Omaha	20	19,110	140	560	19,530
Nev:	Las Vegas [b]	<10	3,960	[c]—	140	4,100
N.H:	Manchester	<10	7,290	140	140	7,290
N.J:	Trenton	<10	7,990	140	140	7,990
N. Mex:	Albuquerque	10	7,450	270	280	7,460
N.Y:	Buffalo	<10	8,720	140	140	8,720
	New York	<10	11,660	140	140	11,660
	Syracuse	<10	9,980	140	140	9,980
N.C:	Charlotte	<10	3,370	140	140	3,370
N.D:	Minot	10	14,770	140	280	14,910
Ohio:	Cincinnati	10	14,320	140	280	14,460
	Cleveland	<10	11,100	140	140	11,100
Okla:	Oklahoma City	30	17,540	140	840	18,240
Ore:	Portland	10	9,630	140	280	9,770
Pa:	Philadelphia	10	10,680	140	280	10,820
	Pittsburgh	<10	14,670	140	140	14,670
P.R:	San Juan [d]	30	4,560	140	840	5,260
R.I:	Providence	<10	8,440	140	140	8,440
S.C:	Charleston	20	6,170	140	560	6,590
S.D:	Rapid City	20	14,110	140	560	14,530
Tenn:	Chattanooga	<10	7,850	140	140	7,850
	Memphis	20	9,630	140	560	10,050
Tex:	Austin	30	10,340	140	840	11,040
	Dallas	30	17,720	140	840	18,420
Utah:	Salt Lake City	20	31,630	270	560	31,920
Vt:	Burlington	<10	8,380	140	140	8,380
Va:	Norfolk	<10	6,410	140	140	6,410
Wash:	Seattle	20	9,650	270	560	9,940
	Spokane	20	21,350	140	560	21,770
W. Va:	Charleston	<10	6,830	140	140	6,830
Wis:	Milwaukee	<10	14,320	140	140	14,320
Wyo:	Laramie	10	19,840	270	280	19,850

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual iodine-131 intake per person from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: (12-month I^{131} index) ($\mu\mu$c day/liter) × (milk consumption factor) (liter/day/person) = (12-month I^{131} intake) ($\mu\mu$c/person)

[b] Station included in network in July 1962. Sums in columns A and D are therefore for 6 and 7 months, respectively.
[c] A dash indicates no analysis.
[d] No sample was received in November 1962. Sums in columns A and D are therefore for 11 months.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK

Sampling locations		Strontium-89 index values ($\mu\mu$c day/liter)*				Strontium-90 index values ($\mu\mu$c day/liter)*			
		Dec. 1961-Nov. 1962 (A)	Dec. 1961 (B)	Nov. 25, 1962-Dec. 29, 1962 (C)	Jan. 1962-Dec. 1962 (D)	Dec. 1961-Nov. 1962 (A)	Dec. 1961 (B)	Nov. 25, 1962-Dec. 29, 1962 (C)	Jan. 1962-Dec. 1962 (D)
Ala:	Montgomery	19,905	620	2,100	21,385	4,950	186	560	5,324
Alaska:	Palmer	17,885	620	1,400	18,665	3,501	279	385	3,607
Ariz:	Phoenix	6,490	620	700	6,570	1,067	62	140	1,145
Ark:	Little Rock	44,550	2,635	6,300	48,215	10,068	527	1,120	10,661
Calif:	Sacramento	6,515	310	700	6,905	1,316	93	140	1,363
	San Francisco	10,850	465	1,225	11,610	1,844	124	175	1,895
Colo:	Denver	10,685	775	525	10,435	3,361	217	385	3,529
Conn:	Hartford	7,610	310	700	8,000	3,833	217	245	3,861
Del:	Wilmington	12,555	620	1,050	12,985	4,544	270	525	4,799
D.C:	Washington	12,295	620	875	12,550	4,817	248	595	5,164
Fla:	Tampa	7,890	310	1,400	8,980	3,326	217	350	3,459
Ga:	Atlanta	28,845	1,240	2,975	30,580	6,178	372	595	6,401
Hawaii:	Honolulu	9,440	620	1,050	9,870	1,989	341	210	1,858
Idaho	Idaho Falls	8,360	155	525	8,730	2,926	186	490	3,230
Ill:	Chicago	10,215	465	1,050	10,800	3,788	217	315	3,886
Ind:	Indianapolis	13,115	620	1,225	13,720	4,732	310	350	4,772
Iowa:	Des Moines	23,295	1,550	1,925	23,670	4,219	248	490	4,461
Kans:	Wichita	17,850	1,240	1,575	18,185	3,881	310	525	4,096
Ky:	Louisville	25,690	1,550	3,500	27,640	6,671	341	700	7,030
La:	New Orleans	64,820	6,355	3,325	61,790	10,401	527	980	10,854
Maine:	Portland	10,355	80	525	10,800	4,763	341	560	4,982
Md:	Baltimore	11,695	930	1,050	11,815	5,057	248	595	5,404
Mass:	Boston	10,845	80	525	11,290	5,477	341	595	5,731
Mich:	Detroit	9,725	465	525	9,785	3,757	186	385	3,956
	Grand Rapids	8,290	465	525	8,350	3,492	217	315	3,590
Minn:	Minneapolis	19,880	620	875	20,135	5,323	310	805	5,818
Miss:	Jackson	55,930	5,425	5,425	55,930	8,427	527	840	8,740
Mo:	Kansas City	28,825	2,170	3,850	30,505	4,852	372	665	5,145
	St. Louis	18,145	620	1,575	19,100	4,601	248	490	4,843
Mont:	Helena	14,955	155	1,225	16,025	3,829	186	560	4,203
Nebr:	Omaha	21,160	2,170	1,750	20,740	4,233	217	560	4,576
Nev:	Las Vegas [b]	3,885	[c]—	875	4,760	819	—	175	994
N.H:	Manchester	9,975	155	525	10,345	4,919	372	525	5,072
N.J:	Trenton	9,515	465	875	9,925	3,950	248	280	3,982
N. Mex:	Albuquerque	5,425	310	1,050	6,165	1,525	124	210	1,611
N.Y:	Buffalo	8,400	155	525	8,770	4,003	248	350	4,105
	New York	10,010	155	700	10,555	4,845	279	385	4,951
	Syracuse	9,010	155	700	9,555	3,774	217	385	3,942
N.C:	Charlotte	19,715	930	1,575	20,360	6,493	372	735	6,856
N. Dak:	Minot	17,490	1,995	875	16,370	5,885	341	1,155	6,699
Ohio:	Cincinnati	17,155	1,550	1,750	17,355	5,067	310	490	5,247
	Cleveland	10,095	310	875	10,660	4,031	217	420	4,234
Okla:	Oklahoma City	24,460	2,170	3,150	25,440	5,611	279	665	5,997
Ore:	Portland	25,150	620	5,075	29,605	4,373	124	630	4,879
Pa:	Philadelphia	9,465	310	1,050	10,205	4,387	279	385	4,493
	Pittsburgh	10,970	155	1,400	12,215	5,366	310	490	5,546
P.R:	San Juan [d]	23,400	4,030	4,550	23,920	3,029	155	455	3,329
R.I:	Providence	8,920	465	525	8,980	4,415	279	385	4,521
S.C:	Charleston	22,385	465	2,800	24,720	6,399	372	805	6,832
S. Dak:	Rapid City [e]	18,560	—	1,225	19,785	4,782	—	700	5,482
Tenn:	Chattanooga	40,190	2,480	4,725	42,435	7,507	496	840	7,851
	Memphis	36,970	2,635	3,850	38,185	7,259	372	700	7,587
Tex:	Austin	9,625	2,015	2,625	10,235	2,394	186	350	2,558
	Dallas	22,750	1,860	6,825	27,715	4,888	248	665	5,305
Utah:	Salt Lake City	10,525	465	875	10,935	2,971	155	350	3,166
Vt:	Burlington	10,425	155	700	10,970	3,964	248	350	4,066
Va:	Norfolk	16,945	1,240	1,400	17,105	5,986	341	700	6,345
Wash:	Seattle	20,510	930	1,925	21,505	5,191	248	490	5,433
	Spokane	12,385	155	875	13,105	4,075	217	595	4,453
W. Va:	Charleston	20,180	620	1,225	20,785	6,267	341	665	6,591
Wis:	Milwaukee	7,700	155	700	8,245	2,952	186	280	3,046
Wyo:	Laramie	17,495	155	1,400	18,740	3,287	155	420	3,552

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-89 and strontium-90 intake per person from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: (12-month Sr^{89} or Sr^{90} index) ($\mu\mu$c day/liter) × (milk consumption factor) (liter/day/person) = (12-month Sr^{89} or Sr^{90} intake) ($\mu\mu$c/person)

[b] Station included in network in July 1962. Sums in columns A and D are therefore for 5 and 6 months, respectively.
[c] A dash indicates no analysis.
[d] No sample was received for November 1962. Sums are therefore for eleven months.
[e] Station began operation in January 1962. December 1961–November 1962 sum is therefore for 11 months.

SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
October 1962

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network, operated by the Public Health Service in cooperation with State and local agencies since 1957, consisted of 123 sampling stations as of the end of October (figure 1). These stations are located on the major waterways used for public water supplies, propagation of fish and wildlife, and recreational, agricultural, and industrial purposes. Samples are taken weekly, monthly, or continuously, depending on the type of analysis and the water quality. These samples are analyzed for plankton population, organic chemicals, chemical, biological, and physical quality, and radioactivity (*1*, *2*).

FIGURE 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, OCTOBER 1962

The radioactivity associated with dissolved solids provides a rough measure of the levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment processes (*3*). It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional beta activity. Gross alpha and beta measurments are made on both suspended and dissolved solids (strontium–90 on the total solids only) in raw surface water samples according to established procedures (*4*, *5*). Because strontium–90 analyses are done quarterly, the results are published on this basis.

For the first two years, beta determinations were made on weekly samples, and alpha determinations were generally made on composites of more than weekly samples. From January 1960 to September 1961, alpha and beta determinations were generally made once a month on weekly composited samples. Begin-

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Average concentrations in pc/liter]

Station	October 1962					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	4	15	19	0	0	0
Animas River: Cedar Hill, N. Mex	5	36	41	2	5	7
Apalachicola River: Chattahoochie, Fla	4	4	8	0	0	0
Arkansas River:						
Coolidge, Kans	6	142	148	0	14	14
Ponca City, Okla	84	44	128	—	—	—
Pendleton Ferry, Ark	—	—	—	—	—	—
Bear River: Preston, Idaho	16	18	34	0	2	2
Big Horn River: Hardin, Mont	27	20	47	5	8	13
Big Sioux River: Sioux Falls, S. Dak	9	26	35	0	3	3
Chattahoochie River:						
Atlanta, Ga	5	5	10	0	0	0
Columbus, Ga	—	—	—	—	—	—
Lanett, Ala	8	10	18	1	0	1
Chena Slough: Fairbanks, Alaska	2	10	12	0	1	1
Clear Water River: Lewiston, Idaho	33	27	60	—	—	—
Clinch River:						
Kingston, Tenn	37	215	252	0	0	0
Clinton, Tenn	11	12	23	0	1	1
Colorado River:						
Loma, Colo	22	47	69	3	9	12
Page, Ariz	—	—	—	—	—	—
Boulder City, Nev	5	34	39	0	11	11
Parke Dam, Calif.-Ariz	6	34	40	0	4	4
Yuma, Ariz	92	16	108	—	—	—
Columbia River:						
Northport, Wash	1	11	12	<1	<1	1
Wenatchee, Wash	0	6	6	0	0	0
Pasco, Wash	32	193	225	0	2	2
McNary Dam, Ore	25	177	202	0	2	2
Bonneville, Ore	—	—	—	—	—	—
Clatskanie, Ore	8	22	30	—	—	—
Connecticut River:						
Wilder, Vt	16	15	21	0	0	0
Northfield, Mass	11	8	19	—	—	—
Enfield Dam, Conn	5	14	19	0	0	0
Cumberland River: Clarksville, Tenn	3	11	14	—	—	—
Delaware River:						
Martins Creek, Pa	6	12	18	—	—	—
Trenton, N. J	16	16	32	0	0	0
Philadelphia, Pa	5	15	20	—	—	—
Escambia River: Century, Fla	—	—	—	—	—	—
Great Lakes:						
Duluth, Minn	1	15	16	0	0	0
Sault Ste. Marie, Mich	2	6	8	0	1	1
Milwaukee, Wis	12	6	18	0	0	0
Gary, Ind	2	7	9	0	0	0
Port Huron, Mich	7	10	17	0	1	1
Detroit, Mich	3	15	18	0	0	0
Buffalo, N. Y	15	9	24	—	—	—
Green River: Dutch John, Utah	19	26	45	0	3	3
Hudson River: Poughkeepsie, N. Y	4	13	17	—	—	—
Illinois River:						
Peoria, Ill	13	24	37	1	0	1
Grafton, Ill	20	24	44	2	<1	2
Kanawha River: Winfield Dam, W. Va	7	5	12	—	—	—
Klamath River: Keno, Ore	—	—	—	—	—	—
Little Miami River: Cincinnati, Ohio	14	31	45	0	2	2
Mississippi River:						
St. Paul, Minn	10	19	29	—	—	—
Dubuque, Iowa	10	16	26	1	3	4
Burlington, Iowa	15	27	42	1	0	1
E. St. Louis, Ill	10	24	34	0	0	0
Cape Girardeau, Mo	72	25	97	4	3	7
W. Memphis, Ark	26	23	49	0	0	0
Delta, La	30	14	44	2	1	3
New Orleans, La	3	20	23	—	—	—
Vicksburg, Miss	24	16	40	2	1	3
Missouri River:						
Williston, N. Dak	32	22	54	—	—	—
Bismarck, N. Dak	12	31	43	0	3	3
Yankton, S. Dak	12	71	83	0	11	11
Omaha, Nebr	10	29	39	—	—	—
St. Joseph, Mo	20	28	48	—	—	—
Kansas City, Kans	31	31	62	9	2	11
St. Louis, Mo	138	36	174	—	—	—
Missouri City, Mo	30	6	36	3	3	6
Rio Grande River:						
Alamoso, Colo	17	37	54	0	3	3
El Paso, Tex	—	—	—	—	—	—
Laredo, Tex	112	12	124	18	9	27
Brownsville, Tex	—	—	—	—	—	—
Roanoke River: John H. Kerr Resr. & Dam, Va	8	15	23	0	0	0
Sabine River: Ruliff, Tex	6	8	14	0	0	0
Sacramento River: Greens Landing, Courtland, Calif	4	10	14	0	1	1
San Joaquin River: Vernalis, Calif	7	22	29	<1	4	4
San Juan River: Shiprock, N. Mex	5	15	20	0	6	6
St. Lawrence River: Massena, N. Y	3	9	12	—	—	—
Schuylkill River: Philadelphia, Pa	6	18	24	—	—	—
Savannah River:						
North Augusta, S. C	2	13	15	—	—	—
Port Wentworth, Ga	5	7	12	0	0	0

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

[Average concentrations in pc/liter]

Station	October 1962					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Shenandoah River: Berryville, Va	15	24	39	0	1	1
Ship Creek: Anchorage, Alaska	6	13	19	0	0	0
Monongahela River: Pittsburgh, Pa	4	29	33	—	—	—
North Platte River: Henry, Nebr	16	48	64	0	20	20
Ohio River:						
E. Liverpool, Ohio	—	—	—	—	—	—
Addison, Ohio	12	28	40	<1	0	<1
Huntington, W. Va	6	21	27	—	—	—
Cincinnati, Ohio	13	26	39	0	0	0
Louisville, Ky	8	22	30	—	—	—
Evansville, Ind	2	15	17	1	3	4
Cairo, Ill	5	21	26	0	1	1
Ouachita River: Bastrop, La	21	17	38	0	0	0
Pend Oreille River: Albeni Falls Dam, Idaho	4	11	15	0	<1	<1
Platte River: Plattsmouth, Nebr	17	26	43	4	2	6
Potomac River:						
Williamsport, Md	—	—	—	—	—	—
Great Falls, Md	2	12	14	—	—	—
Rainy River:						
Baudette, Minn	5	26	31	0	0	0
International Fls., Minn	3	18	21	0	0	0
Red River, South:						
Index, Ark	20	52	72	—	—	—
Alexandria, La	53	56	109	1	2	3
	41	22	63	0	0	0
Snake River:						
Ice Harbor Dam, Wash	5	22	27	0	1	1
Wawawai, Wash	15	22	37	0	2	2
Payette, Idaho	7	18	25	0	3	3
South Platte River: Julesburg, Colo	30	104	134	2	55	57
Spokane River: Post Falls, Idaho	11	7	18	0	0	0
Susquehanna River:						
Sayre, Pa	12	23	35	—	—	—
Conowingo, Md	2	12	14	—	—	—
Tennessee River:						
Chattanooga, Tenn	6	20	26	0	0	
Bridgeport, Ala	—	—	—	—	—	—
Pickwick Landing, Tenn	7	21	28	1	0	1
Lenoir City, Tenn	4	10	14	0	<1	<1
Tombigbee River: Columbus, Miss	11	16	27	0	2	2
Truckee River: Farad, Calif	—	—	—	—	—	—
Verdigris River: Nowata, Okla	33	25	58	<1	<1	1
Wabash River: New Harmony, Ind	23	74	97	1	<1	1
Yakima River: Richland, Wash	10	14	24	0	1	1
Yellowstone River: Sidney, Mont	150	26	176	3	3	6

ning in September 1961, alpha determinations have been made on one sample each month, and beta determinations have generally been made on weekly samples. For the first operating year of each new station, sampling, and alpha and beta analysis are done weekly.

If at any time activity significantly greater than the normal environmental levels has been noted, the rate of sampling and analysis has been increased to at least one every week. Since January 1959, a portion of each sample from all stations in the network has been composited into a three-month station sample for measurement of strontium–90 (*6*).

Table 1 presents the results of the alpha and beta analyses on raw surface water in the United States for October 1962.

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RADIOACTIVITY IN CALIFORNIA SURFACE WATER 1961–June 1962

Bureau of Radiological Health
State of California,
Department of Public Health

In March 1960 the Bureau of Radiological Health was formed in California's Division of Environmental Sanitation. This Bureau is responsible for environmental radiation surveillance.

The Bureau was established in recognition of the need for baseline data and continuing monitoring in order to pinpoint environmental radiation problems well before a level of acute concern is reached. Domestic water was one item selected for monitoring by the Bureau.

Procedure

Most of California's domestic water supplies come from surface sources. Radioactivity in such water supplies consists of the natural radioactivity in surface streams and any radioactivity that may be added by the discharge of sewage or industrial waste effluents into streams. These water supplies may also contain radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Most of the supplies sampled represent raw surface waters (see figure 2) although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

It is necessary to monitor domestic water supplies on a continuous basis, since it is impossible to forecast levels of radioactivity in these supplies on the basis of radioactivity in rain, snow, or surface streams. The California Bureau has established a monthly sampling schedule whereby 500 ml samples are collected and the total solids are analyzed for alpha and beta radioactivity. In addition, a three-liter sample is collected each month for a period of six months to make up a composite of approximately five gallons for strontium–90 analysis.

Laboratory Methods

All measurements of alpha and alpha plus beta activities are made with windowless, gas-flow, proportional counters. These counting devices have two decided advantages: (1) windowless counting provides geometry, thereby giving efficiencies of about 60 percent for thallium–204 or cesium–137 sources, both of which have been used for calibration, and (2) proportional counters can be used to separately measure alpha and beta radioactivity by simply adjusting the high voltage, thus eliminating the need for two types of detectors.

FIGURE 2.—CALIFORNIA SURFACE WATER SAMPLING STATIONS

Five proportional counters, four of which are manual counters, are available to the California Bureau. The manual counters accept samples up to two inches in diameter. Two of these manual units have shielded external detectors which reduce the alpha and beta backgrounds to 0.01 and 30 cpm respectively. The other two manual counters are of integral construction with the unshielded detector built into the scaler housing. The relatively high beta background of these units has been reduced to 40 cpm by shielding the entire scaler with lead bricks.

The fifth counter is an automatic unit composed of a sample changer, detector, scaler, and a printer-timer. The detector accepts samples

up to 1½ inches in diameter and has a beta background of about 15 cpm.

The Bureau's maximum capacity for alpha and beta radioactivity measurements during a normal work week is 500 thirty-minute counts.

Discussion

Tables 2 and 3 show the monthly average beta activity in the suspended plus the dissolved solids in raw surface water in California from January 1961 through June 1962. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has been, in general, not detectable or very slight, the results of alpha activity analyses are not presented.

Data from the years 1961 and 1962 for a few selected sampling points in different parts of the State are presented in Table 4. The data in this table are six-month averages. California annually experiences both a wet and a dry season with an accompanying heavy or light runoff, respectively. The period January through June corresponds to the wet season with the balance of the year being the dry season. If the dry seasons of 1961 and 1962 are compared, or if the wet seasons of 1961 and 1962 are similarly compared, it may be observed that there was a general increase in beta activity from 1961 to 1962. Although the increases are significant statistically, the levels do not represent any significant health hazard.

TABLE 2.—GROSS BETA ACTIVITY IN CALIFORNIA SURFACE WATER, 1961

[Concentrations in μμc/liter]

Sampling station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Antioch	[a]	3.6	20.5	10.2	7.4	[a]	8.5	13.1	[a]	[a]	24.3	22.0
Clearlake Highlands	[a]	[a]	[a]	8.3	8.8	12.3	16.5	14.4	14.4	16.2	12.4	17.9
Dos Palos	[a]	[a]	[a]	14.2	[b] —	—	[a]	17.7	—	5.4	—	—
Escondido	—	—	4.5	13.5	15.3	13.5	—	[a]	[a]	19.9	49.4	34.5
Eureka	[a]	[a]	3.8	[a]	98.8	[a]	4.3	—	—	6.0	74.2	45.2
Fort Bragg	[a]	[a]	[a]	[a]	43.1	2.7	3.3	[a]	3.6	31.7	5.9	47.1
Fresno												
Lake Millerton	[a]	[a]	23.4	56.9	53.7	2.5	3.7	7.2	[a]	[a]	23.6	17.7
Los Angeles Metropolitan Water District												
Lake Havasu	11.6	[a]	47.2	32.0	30.9	12.0	—	—	109.8	15.8	—	27.2
Lake Matthews	—	—	—	—	27.8	3.8	13.8	[a]	16.2	[a]	[a]	18.2
Marin Municipal Water District												
Alpine Dam	2.9	[a]	[a]	[a]	2.8	21.2	—	3.8	—	—	37.7	—
Mill Valley Reservoir	[a]	[a]	[a]	[a]	3.6	3.5	[a]	[a]	—	13.1	—	—
North Marin County Water District	8.8	7.3	5.4	8.2	42.3	34.0	10.3	12.4	—	18.1	37.8	—
Monterey	[a]	[a]	7.7	15.6	[a]	[a]	[a]	[a]	[a]	11.3	[a]	32.8
Napa	—	[a]	[a]	19.7	28.4	70.1	5.5	[a]	4.7	27.1	[a]	25.8
Placerville	8.0	[a]	34.5	42.7	[a]	4.6	—	16.1	12.3	[a]	—	73.4
Redding	[a]	[a]	[a]	6.1	31.2	4.5	10.0	[a]	[a]	6.7	—	21.7
Sacramento	2.9	6.8	9.8	12.6	—	—	9.5	16.1	[a]	20.2	13.7	29.8
San Diego												
Alvarado Filter Plant	[a]	[a]	[a]	19.0	26.0	14.2	18.3	—	14.6	22.2	31.7	15.8
El Capitan Reservoir	8.2	5.7	3.3	—	29.6	—	—	—	14.3	87.9	—	—
Sutherland Reservoir	8.7	8.8	4.9	—	32.1	—	—	—	23.3	—	33.5	—
San Francisco Water Department												
University Mount	[a]	[a]	4.4	9.3	—	5.0	11.4	[a]	2.8	17.9	40.7	22.0
Calaveras Reservoir	[a]	4.9	[a]	50.5	4.1	[a]	9.1	[a]	15.8	5.7	57.1	24.2
Alameda East	[a]	[a]	[a]	77.6	6.7	9.9	7.0	[a]	15.8	14.0	33.9	11.0
San Andreas Line #1	[a]	[a]	2.9	10.5	—	3.9	[a]	[a]	—	—	57.2	—
San Francisco Water Department, Con.												
San Andreas Line #2	[a]	[a]	4.8	5.5	—	[a]	[a]	[a]	3.6	22.0	41.1	41.6
Crystal Springs Reservoir	[a]	[a]	[a]	3.7	—	4.5	7.6	[a]	[a]	13.1	28.7	25.4
Crystal Springs Line #1	[a]	[a]	5.0	39.9	—	6.5	6.3	[a]	4.8	[a]	36.9	24.6
Lombard Reservoir	[a]	[a]	[a]	14.1	3.4	5.2	[a]	[a]	[a]	[a]	30.3	12.1
San Jose	[a]	[a]	[a]	40.4	71.6	[a]	9.5	[a]	—	—	—	—
San Luis Obispo	—	—	—	—	11.8	7.4	82.0	[a]	5.8	19.6	11.4	54.5

[a] No significant activity.
[b] Dash indicates no sample collected or analyzed.

TABLE 3.—GROSS BETA ACTIVITY IN CALIFORNIA SURFACE WATER, 1962

[Concentrations in μμc/liter]

Sampling station	Jan	Feb	Mar	Apr	May	Jun
Antioch	36.2	88.2	31.9	27.9	7.3	16.7
Clearlake Highlands	24.0	249.8	55.4	47.2	26.8	23.4
Crescent City	[a]	[a]	11.1	25.2	19.6	27.3
Escondido	34.7	81.2	[b] —	43.6	45.9	22.2
Eureka	72.7	58.1	29.8	38.6	4.2	21.1
Fort Bragg	47.2	31.5	218.1	30.8	—	9.3
Fresno						
Lake Millerton	[c]20.7	[c]58.5	[c]33.0	[c]45.2	[c]44.2	[c]29.8
Los Angeles Metropolitan Water District						
Lake Havasu	—	35.1	23.9	27.7	—	—
Lake Matthews	29.0	26.1	37.1	37.8	19.3	—
LaVerne Treatment Plant	—	—	—	—	17.5	7.4
Marin Municipal Water District	27.5	36.3	43.8	—	46.7	29.7
North Marin County Water District	—	—	69.8	60.5	31.8	46.2
Mariposa	—	34.8	40.0	18.0	45.3	31.5
Monterey	20.8	[a]	67.6	[a]	10.6	7.0
Napa	22.4	38.3	41.6	20.9	30.3	29.2
Placerville	[a]	49.6	22.6	28.3	35.7	7.0
Redding	[c]27.6	27.0	48.9	35.6	28.4	42.4
Sacramento	[a]	41.7	—	11.9	13.6	12.5
San Francisco Water Department						
University Mount	29.5	49.4	—	59.8	37.5	30.8
Calaveras Reservoir	24.0	37.9	35.6	37.8	35.1	19.2
Alameda East	[a]	40.1	1.7	45.8	31.9	47.8
San Andreas Line #2	12.6	[c]60.5	[c]56.7	[c]34.2	[c]24.0	[c]31.9
Crystal Springs Line #1	—	29.9	[c]33.2	[c]42.8	18.6	[c]26.2
Crystal Springs Line #2	13.4	[c]23.1	—	17.0	20.6	28.6
Crystal Springs Raw Outlet	—	27.7	77.2	47.8	42.9	24.2
Lombard Reservoir	50.4	76.6	46.0	14.1	29.9	—
Brightside Weir	—	17.5	34.0	102.9	40.6	[a]
Hetch Hetchy	—	—	—	—	62.2	56.2
San Jose	—	—	—	25.6	10.4	19.7
San Luis Obispo	[a]	33.3	114.7	6.5	58.5	20.2
Santa Barbara	67.9	26.0	[a]	16.7	—	40.3
Santa Cruz						
Coastal Water	[a]	269.0	83.0	34.1	[a]	1.8
Santa Rosa	[a]	—	33.8	23.1	1.7	[a]
Scotia	18.9	197.1	65.1	19.7	—	8.6
Tahoe City	16.1	[a]	64.2	47.5	30.4	17.2
Vallejo						
Fleming Hill	55.6	284.0	73.6	39.4	19.7	17.6
Swanzy Reservoir	[a]	63.9	15.4	35.2	35.3	21.6
Vista	61.5	81.2	48.6	22.2	70.9	25.2
Willits	60.2	104.1	21.6	43.8	36.3	26.2
Yosemite	[c]13.4	49.1	65.3	69.1	41.8	31.7

[a] No significant activity.
[b] Dash indicates no sample collected or analyzed.
[c] Average of more than one sample for the month.

TABLE 4.—SIX MONTH AVERAGE OF GROSS BETA RADIOACTIVITY IN RAW WATER IN SELECTED CALIFORNIA CITIES*

[Concentrations in μμc/liter]

City	Jan–June 1961	July–Dec. 1961	Jan–June 1962	July–Dec. 1962
Clearlake Highlands	4.9	15.3	35.4	17.8
Fort Bragg	7.6	15.3	29.9	37.3
Lake Millerton	22.8	8.7	38.6	14.0
Monterey	3.9	7.3	17.7	13.8
Placerville	15.0	25.5	23.9	12.3
Redding	7.0	7.7	35.0	19.0
Sacramento	8.0	14.9	15.9	9.2
San Jose	18.7	4.8	18.6	6.6

* Averages based on at least three monthly values.

Radioactivity in Minnesota Surface Water
April–November 1962

Division of Environmental Sanitation, Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled, but 7 surface streams and lakes involving 11 stations are now sampled routinely (see figure 3). Grab samples of raw and treated water are collected weekly at each station with the exception of the Crookston, Elk River, International Falls, and St. Cloud stations, where monthly samples are collected.

The samples are forwarded to the Division's laboratory where they are analyzed for gross beta activity. A 250 ml sample of water is evaporated at 75° C. from a planchet. The solid residue (suspended plus dissolved solids) is fixed by adding lucite in acetone. Afterwards, this sample is counted with either an internal proportional counter or a thin end-window

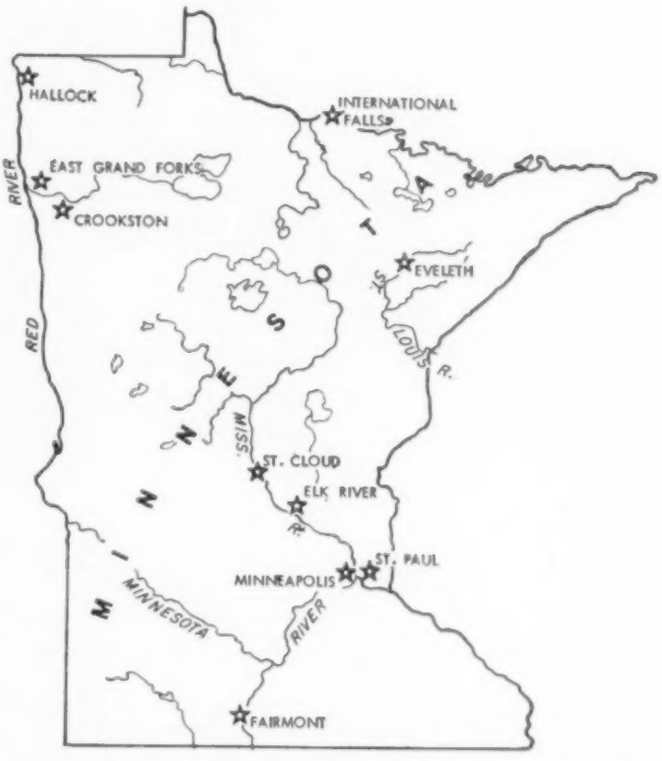

FIGURE 3.—MINNESOTA SURFACE WATER SAMPLING LOCATIONS

TABLE 5.—TOTAL BETA CONCENTRATION IN MINNESOTA RAW AND TREATED WATER FROM SURFACE SUPPLIES, APRIL–NOVEMBER 1962

[Concentration in $\mu\mu$c/liter]

Town and water source	Type of water	April	May	June	July	August	September	October	November
Crookston, Red Lake River	raw	[a]—	51	120	97	98	49	37	30
	treated	—	40	85	56	29	15	26	33
Elk River, Mississippi River	raw	—	—	—	—	32	58	—	—
	treated	—	—	—	—	—	—	—	—
East Grand Forks, Red Lake River	raw	79	104	112	55	42	42	36	35
	treated	44	43	55	51	12	28	17	18
Eveleth, St. Mary's Lake	raw	[b]	36	52	23	47	26	19	31
	treated	[b]	25	33	36	31	13	16	27
Fairmont, Budd Lake	raw	31	44	64	51	23	26	49	29
	treated	[b]	27	15	21	23	27	8	16
Hallock, Two Rivers South Fork	raw	69	94	135	151	78	64	43	68
	treated	41	42	55	89	27	39	16	50
International Falls, Rainy River	raw	—	15	47	77	49	—	47	33
	treated	—	[b]	22	44	[b]	—	36	24
Minneapolis Tap Water	raw	—	—	—	—	—	—	—	—
	treated	—	32	20	11	—	11	—	[b]
St. Cloud, Mississippi River	raw	—	[b]	96	35	—	[b]	[b]	24
	treated	—	20	44	42	—	[b]	[b]	[b]
St. Paul Vadnais Chain of Lakes	raw	[b]	[b] 58	59	45	44	47	40	10
	treated	[b]	[b] 13	8	49	21	27	6	7

[a] Dash indicates no analysis performed.
[b] Letter indicates nondetectable beta activity.

proportional counter. Counter standardization is accomplished by adding known amounts of thallium–204 standard to solutions containing the normal range of solids.

Table 5 shows the monthly average gross beta activity in Minnesota surface water from April through November 1962. The nondetectable (ND) values shown indicate that the activity was indistinguishable from background. In averaging, ND values are assumed to be zero except when the values to be averaged consist of only ND values; then the average is reported as ND.

The data obtained on gross beta activity in Minnesota surface waters show a random variation of concentrations, with no readily apparent trends. Variation in precipitation and flow rates of streams could contribute to this variation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from nondetectable to 151 μμc/liter. Individual samples had concentrations that ranged from nondetectable to 220 μμc/liter.

SECTION V.—OTHER DATA

Tri-City Diet Study—Stable Strontium and Calcium Diet/Bone Observed Ratios, 1962*

Joseph Rivera
Health and Safety Laboratory, U.S. Atomic Energy Commission

One aspect of the program of investigation at the Health and Safety Laboratory on the passage of strontium–90 through food chains to man has been the determination of the concentrations of stable strontium present in the various components of the food chain and in man's skeleton. Estimates of stable strontium intake by residents of New York City, Chicago, and San Francisco were made in the last quarterly report (HASL–131) (*1*, *2*). The ratios of stable strontium to calcium in the diets from these cities were 1.5, 2.3 and 3.4 mg/g Ca, respectively.

An estimate of the degree of discrimination by the body between strontium and calcium can be made by comparing the ratio of these elements in the diet with the ratio found in bone Observed Ratio (OR).

Data on the stable strontium content of human vertebrae obtained in New York City, Chicago, and San Francisco are presented in table 1.

A summary of the data presented in table 1 and the Observed Ratios found at the three cities is presented in table 2. The average calcium concentration found in the ashed vertebrae was 37%. This result has been used in calculating the Sr/Ca ratios.

Discussion

The data show, as expected from the diet data, that on the average there is more stable strontium in the bone specimens obtained in the San Francisco area than those obtained in New York City, with samples from Chicago having intermediate concentrations. Although, there are relatively few samples, the general distribution of Sr/Ca ratios with age at each of the cities is similar to that found by Bryant and Loutit for human bone samples obtained in the United Kingdom (*3*).

The calculated Observed Ratios are consistently lower than was expected. Bryant and Loutit obtained a bone/diet OR of 0.25, a result which is consistent with other experiments using double tracer techniques as well as estimates made from strontium–90 measurements in human bone (*4*).

It is noteworthy, however, that despite this difference from the expected value, the OR is approximately the same for the three cities although the stable strontium intake varies by more than a factor of two.

Before the conclusion can be accepted that there is in fact more discrimination by the

* Data from *Quarterly Summary Report, HASL–12*, January 1, 1963.

TABLE 1.—STABLE STRONTIUM IN HUMAN VERTEBRAE

Age at death (years)	New York City		Chicago		San Francisco	
	ppm[a]	μg/g Ca[b]	ppm[a]	μg/g Ca[b]	ppm[a]	μg/g Ca[b]
0–1	51	138	96	259	93	25
1–2	45	122			122	32
2–3	57	154	[c]72	[c]208		
3–4	55	149	65	176	104	28
4–5	66	178	116	313	143	38
5–6	68	184				
6–7	66	178	61	165		
7–8	76	205	73	197	85	23
9–10	89	240	70	189		
10–12	78	211	133	359	115	310
12–14	67	181			77	208
14–16	146	394	68	184	179	483
16–18	65	176	71	192		
18–20	81	219	73	197		
20–40	[c]76	[c]204	[c]113	[c]305	[c]89	[c]241
40–60	[c]114	[c]308	[c]98	[c]264	[c]105	[c]282
>60	[c]78	[c]211	[c]113	[c]304	[c]376	[c]1,014

[a] Parts per million in ash.
[b] Assuming 37 percent calcium in ash.
[c] Average of two samples.

TABLE 2.—STABLE STRONTIUM IN BONE AND DIET

City	Average mg Sr/g Ca				Average bone/diet observed ratios
	Diet	Vertebrae			
		Age < 20 years[a]	Age > 20 years[a]	Average of < 20 & > 20	
New York	1.5	0.195	0.241	0.218	0.15
Chicago	2.3	0.221	0.291	0.256	0.11
San Francisco	3.4	0.310	0.512	0.411	0.12

[a] Averaged from data in table 1.

body against strontium in favor of calcium than was previously thought, several sources of potential error in O.R. estimates must be considered.

Most of the analyses of foods as well as bone were done by emission spectroscopy. A quality control program, intercomparing samples with results obtained by neutron activation analysis and by flame photometry on all types of matrices, showed generally good agreement between methods. The estimated precision of the analyses was ± 5%. There was no evidence that bone samples were giving systematically lower results than food samples.

It is possible that the estimates of the stable strontium intake at the three cities is in error, but if this is the case it is likely that the estimate is too low rather than too high since some

items which may contribute substantially to the annual intake of stable strontium have been excluded, e.g. tap water.

Another possible source of error is that vertebrae may not have the same strontium content as other parts of the skeleton. However, this possibility does not seem likely on the basis of the observations of Thurber, et al. (*5*) on the variability of strontium concentrations between bones in eleven cadavers.

These findings suggest that if there is an error in the calculated OR it is probably due to an inadequate sample size. More data are being obtained on the stable strontium content of foods and human bone so that the validity of this method for the estimation of strontium-calcium discrimination can be more accurately established.

Conclusion

The average Bone/Diet ratio of the stable strontium to calcium ratio was found to be about 0.13. If this number is correct, the body in fact has a considerable (7.7 to 1) preference for calcium rather than strontium. The major source of error is the small sample size.

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Radiation Exposure From Luminous Watch Dials[1]

W. Seelentag and H. Schmier[2]

The first Radiation Protection Regulation of June 24, 1960, of the Governmental Health Agency (West Germany) considers all radiation exposure of natural or artificial origin, including that from luminous paints. In the section on luminous paints incorporating radioactive substances (*1*) firmly adherent luminous paints do not require special approval if:

(a) they do not exceed a limit of 10 microcuries, except for radium, and

(b) the dose emitted from the uncovered source of radiation at a distance of 0.1 meter does not exceed 0.1 millirem per hour.

The regulation applies to both the manufacture and repair of such watch dials. Permissible "activating" materials are only relatively small amounts of radiotoxic substances, exclusive of radium. This includes promethium–147 or tritium, but not strontium–90, which has been used recently by various [non-German] firms (*2*, *3*). Strontium–90-activated dials are not admitted to free sale in German commerce.

Formerly, fluorescent materials to induce luminescence consisted mainly of so-called technical mesothorium (according to W. Minder (*4*), this meant about 70 percent mesothorium and radiothorium and about 30 percent radium). In recent years, pure radium predominated (oral communication from Minder), whereby alpha activity served as the main means for producing fluorescence, while the beta activity and accompanying gamma rays produce an unwanted side effect contributing to the much discussed radiation exposure of the wearer. Currently, efforts are being made to achieve the use of pure alpha or beta sources, such as promethium–147 and tritium, to minimize the dose of unwanted gamma rays received by the wearer.

The official limit for a radiation exposure from an uncovered timepiece is 0.1 mrem/hour

[1] Abstracted from *Bundesgesundheitsblatt*, No. *16*: 285–8 (1961).

[2] Prof. Seelentag is Director and Dr. Schmier is Scientific Counsel with the Institute for Water, Soil and Air Hygiene, National Department of Health, Berlin-Dahlem, Germany.

TABLE 1.—RADIUM CONTENT OF LUMINOUS DIALS OF MEN'S WRIST WATCHES

Author, locality	Year observations	μg radium equivalent	
		Average value	Minimal maximal range
Brit. Med. Res. Council (7)	1956	0.2	
Glaser, Schramberg (8)	1957	0.035	(0.03 –0.042)
Ibid	1958	—	(0.045–0.100)
Joyet, Zurich	1958	0.36	(0.06 –0.81)
Ibid	1960	0.144	(0.106–4.46)
Flatby & Koren, Oslo	1959	0.19	
(According to Seelentag)	1959 (according to taxes on paint)	—	(0.006–0.165)
Seelentag & Klotz, Munich	1959	0.04	(0.008–0.095)
Berlin	1961	0.014	(0.002–0.045)
	German makes (omitting extremes) Swiss makes (few specimens)	0.070	(0.013–0.175)
	All watches (including extremes)	0.063	(0.002–0.885)

from a distance of 10 cm. This means 0.88 rem/year, or less than one-fifth the established occupational whole-body dose. Watches that do not meet this requirement should not be permitted to be sold.

Whether the watch user receives an undesirably high or even harmful dose should be considered from three points of view:

1. According to the physical dosimetric or physical amount of activity, i.e., the effective amount of radiation.
2. Biological-medical aspects, which is concerned with harmful or potentially harmful effects, and
3. According to whether the radiation exposure is limited or general.

Judgement will depend on such questions as the consequences and possible benefits of procedures, as in X-ray diagnostic procedures wherein a certain exposure might be justified.

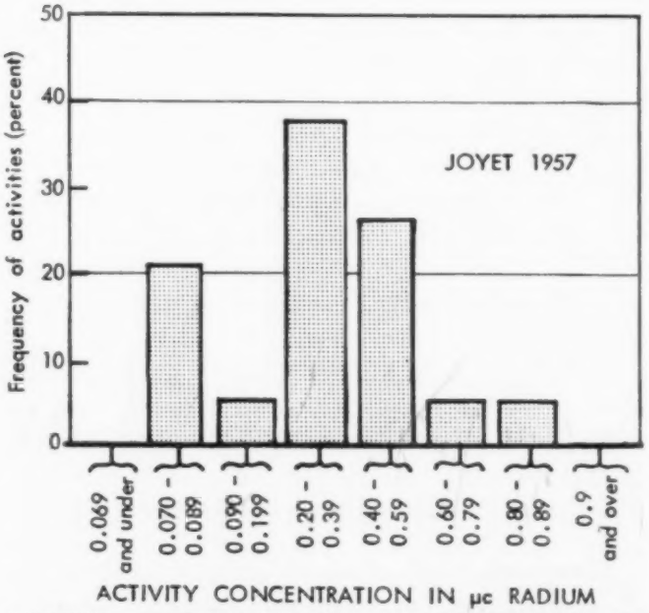

FIGURE 1.—PERCENTAGE DISTRIBUTION OF TEST WATCHES GROUPED ACCORDING TO ACTIVITIES

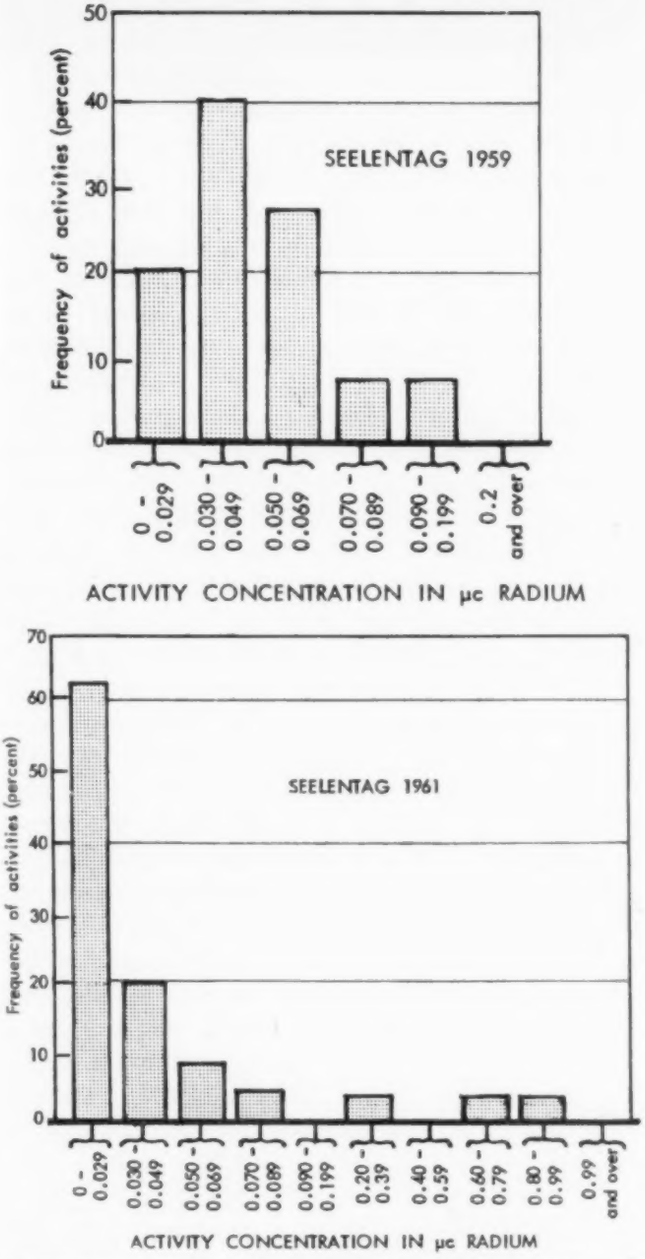

FIGURE 1.—PERCENTAGE DISTRIBUTION OF TEST WATCHES GROUPED ACCORDING TO ACTIVITIES—CONTINUED

The physical-dosimetric quantities depend primarily in the amount of radioactive substance present, and secondarily on the way the timepiece is used (as wristwatch, alarm clock) and on the time involved in its use (day and night, days only, nights only).

Literature accounts of the radium content of dials are assembled in table 1; these data are supplemented by the authors' recent findings. Figure 1 charts percentagewise the distribution of activity in watches examined, as reported by Joyet (*3*) in 1957, Seelentag and Klotz (*5*) in 1959, and our findings in 1961. It can be seen that considerable differences in activity exist among the timepieces examined. Furthermore, there was observed in Germany during the years 1958–1961 a notable tendency for the amount of activity to diminish. In watches examined in 1961, those with higher activity (in excess of 0.1 μg radium equivalent) were represented chiefly by so-called sport watches. The maximum value of 0.9 μg radium equivalent was obtained for an older model which had a luminous circle. The median values shown in table 1 were markedly affected by these relatively few watches and would have been much lower if they were omitted. Watches with ratings of about 5 μc radium, the extreme value found by Joyet, did not appear in our series.

With knowledge of the radioactivity present in the watch, the radiation exposure of the user can be calculated relatively easily. The values calculated by Seelentag and Klotz in 1959 are given in table 2. The assumption was made (for wrist watches) that the average distance from the gonads was 30 cm, and the wearing time, 24 hours daily; for alarm clocks, the assumption was a 1-meter distance and 8 hours daily exposure.

TABLE 2.—RADIATION EXPOSURE OF INDIVIDUALS FROM LUMINOUS DIALS*

(after Seelentag & Klotz, 1959)

Type of timepiece	Average radium content (μg)	Dose μr/hour	Yearly dose mr
Large alarm, at 1 meter, 8 hrs/day	0.12	0.15	0.4
Travel alarm, at 1 meter, 8 hrs/day	0.08	0.10	0.3
Ladies wrist watch, at 3 cm., 24 hrs/day	0.010	0.15	1.3
Men's wrist watch at 30 cm., 24 hrs/day	0.04	0.6	5.3
Men's wrist watch, local (forearm)		300	2600

* Calculated on basis of scattering of 50 percent for whole body-gonadal dose, and 20 percent local dose to forearm.

Exposure due to beta radiation, which occurs in time through the watch glass, was not included in the calculations, since its body penetration was a few millimeters at most; so that any noticeable effect on the whole body, the blood-forming organs, or the gonads would not be anticipated. In the last line of table 2, the local exposure to the forearm is given for wristwatches. The beta radiation to the skin

need not be counted, since it would be completely absorbed by the case and mechanism.

Joyet (*3*), and Flatby and Koren (*6*) measured radiation doses in persons for whom special watches or plexiglass blocks were prepared and worn, which emitted about 100 times the normal activity. Their dosage measurements were in agreement with our calculations. Table 3 presents these dosage values; the calculated values were somewhat higher, apparently because the average distance to the gonads was somewhat greater than the assumed 30 cm. An interesting feature of the measurements of Flatby and Koren is the observation that the gonadal exposure during the 16 daylight hours was only about one-fifth of what it measured when the watch was also worn nights.

From the biological-medical point of view, we must distinguish between the radiation to the whole body (general somatic activity), to limited parts of the body surface (local somatic activity) and to the genetic substance, which involves the possibility of genetic damage. One can proceed from the radiobiological findings and knowledge of the radiation doses at which no effects have as yet been observed; from this one can calculate the so-called maximum permissible occupational radiation dose which, according to the recommendations of both the International Radiation Protection Commission and the German Radiation Protection regulations, establishes a safety factor of more than 10. These recommendations are used also in connection with the local exposure to the forearm resulting from the wearing of wristwatches.

Since we do not know the threshold level below which certain effects of radiation to the whole body and especially mutative effects may occur, we have to use as our base for the general somatic and genetic activity the so-called natural background radiation, which for millions of years has acted on man and all living things on earth. We may assume that radiation levels in the order of natural radiation and variations thereof have no greater effects than other factors that exist in our enviroment. From the point of view of genetics, however, we must take into account that modern man has been able to generate various artificial sources of radiation, introducing the danger that their sum may overstep allowable limits.

Whole-body dose can be correlated, in general, with gonadal dose. For purposes of reference for both, table 3 gives this in terms of percentage of natural radiation received by the wearer of the wrist watch over the period of a year. In the majority of cases, this amounts to 1–4 percent, but can reach more than 75 percent in the cases of watches with highest activity measured by us, and more than twice the natural radiation for the extreme values reported by Joyet. It must be repeated, however, that the dosage limitation by the radiation protection regulations alone restrict gamma radiation of watches to a maximum of 1 μc radium!

TABLE 3.—RADIATION EXPOSURE FROM WRIST WATCHES OF DIFFERENT ACTIVITIES

Author	Activity (μg radium equivalent)	Gonadal whole body dose		Local dose, forearm	
		mr/yr	Percent of natural radiation[1]	mr/yr	Percent of MPD[2]
Seelentag & Klotz, 1959	0.04	5.3	3.5	2,600	4.3
Seelentag & Schmier, 1961	0.014	1.8	1.2	850	1.4
(minimum value)	0.002	0.3	0.2	122	0.2
(maximum value)	0.885	115	77	54,000	90
Flatby & Koren	0.19	23	15	—	—
Flatby & Koren[3]	0.19	4.4	2.9	—	—
Joyet (men's watches)	0.14	9.8	6.5	—	—
Joyet (ladies' watches)	0.06	3.9	2.6	—	—
Joyet (maximum value)	4.5	310	210	270,000	450
[For comparison and correlation against other activities:					
Seelentag	1.0	130	Approx. 90	Approx. 60,000	100
Flatby, 24 hrs	1.0	120	Approx. 80		
Flatby, (days only)	1.0	23	Approx. 15		
Joyet (men's watches)	1.0	70	Approx. 50		
Joyet (ladies' watches)	1.0	65	Approx. 40		

Note: Doses of Seelentag and coworkers are calculated, and those of Flatby and Koren, as well as Joyet, measured on wearers of watches which had up to 100 times the activity of normal illuminated dials.

[1] Background radiation of 150 mr/year assumed, which compares with the ICRP maximum permissible whole body dose of 170 mr/year for the total population.

[2] MPD = Maximum permissible dose (occupational rate) for local forearm for year = 60 r = 60,000 mr.

[3] Daytime wearing only (in the row above, however, night wearing is calculated into the estimates). Watches with higher activity should not be worn nights, since apparently daytime distance from gonads is less than that at night.

Local exposure to the forearm is given in terms of maximum permissible occupational dose. It is generally in the order of 1.5–4.5 percent of this maximum permissible dose, but in the example of our "most active" time-piece it can reach nearly 100 percent if worn on a 24-hour basis. In Joyet's series, the maximum permissible dose can be exceeded by 3 or 4 times in watches of highest activity.

For estimation of genetic activity, it is not only meaningful to know what radiation levels are received by the gonads of the individual wearers of the watches, but it is more important to consider the frequency with which such watches are worn by the population as a whole, and what might be the "average probable reproductivity of the wearer"; i.e. the age distribution of the wearers. Seelentag and Klotz (*5*) calculated this so-called average genetic dose and arrived at a figure of 2 percent of natural background. At the established reduction for average activity for German watches, and also considering a reduction in numbers of such watches—fewer than 50 percent of men's wrist watches of recent manufacture have luminous dials—the average genetic dose should be less than 1 percent of natural radiation.

The radiation exposure from luminous dials of alarm clocks may be considered negligible, certainly by comparison with wrist watches.

SUMMARY

In the first Regulations for Radiation Protections, paragraph 11 contains definitions of harmful or dangerous activity concentrations for radiation from luminous dials for individuals. Recent measurements of wrist watches show a definite trend toward a reduction in such activity. In the case of German-made watches, at least, most have radium amounting to less than 0.06 and usually only about 0.02 μg. The radiation dose to wearers of such watches amounts to only a small percentage of the natural background radiation. The local dose to the skin of the forearm ranges around a few percent of the maximum permissible occupational dose. Exceptions, however, are found among watches of foreign [non-German] manufacture, especially so-called sport watches, which may give a whole body radiation exposure in the order of magnitude of natural background radiation, and local forearm dose up to the maximum permissible occupational dose or even higher. Such watches should not be worn all day, and should at least not be worn at night. Somatic manifestations, such as effects on the blood picture, or local erythema, or pigmentation of the forearm, do not occur even in the latter cases; when they occur, it is due to causes other than ionizing radiation.

Moreover, the average genetic dose from these timepieces to the population appears to be relatively insignificant, according to current estimations; it amounts to only about 1 percent of natural background radiation exposure. Nevertheless, it should be a basic rule that every artifical radiation exposure is undesirable unless—as in the use of ionizing radiation in medicine—it is justified.

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Whole Body Counting

Whole body counters are being applied where the detection of low levels of radioactivity in the human body is important. One example is the evaluation of hazards to radiation workers and the general population. These instruments are also used in human physiological and pathological investigations as well as in studies related to counter design for special purposes. Discussion and presentation of whole body counting results in previous issues of *Radiological Health Data* have been limited to medical research programs employing thallium-activated sodium iodide crystals or liquid scintillation solutions.

GEOGRAPHICAL DISTRIBUTION OF CESIUM–137 IN MAN
July 1958 through September 1962

Walter Reed Army Institute of Research

In 1955, cesium–137 was first detected in man at the Argonne National Laboratory (*1*). It emits a 0.661 Mev gamma photon, which can be quantitatively determined by a properly calibrated whole body counter. Since cesium is physiologically similar to potassium, and for the most part exists intracellularly, the cesium–137 levels are usually expressed in micromicrocuries per gram of potassium. The Walter Reed Army Institute of Research, in its program for measuring the cesium–137 levels in man, utilizes a liquid scintillation counter at Landstuhl, Germany (*2*) and at Washington, D.C. (*3*), and a thallium-activated sodium iodide crystal in a low background shield (*3*) at Washington, D.C. The analyses for cesium–137 have been carried out since 1958.

Previously published data for the period July 1958 through August 1962, together with additional data from Landstuhl, Germany, for September 1962 are summarized herein (in table 1) for the first time by principal geographical areas of residence. Although the effect of latitude on the cesium–137 burden in man is not readily apparent from the data, some geographical variation can be noted. Residents of Europe, including West Germany, as shown in figure 1, have higher cesium–137 body burdens on the average than residents in the United States and the Far East.

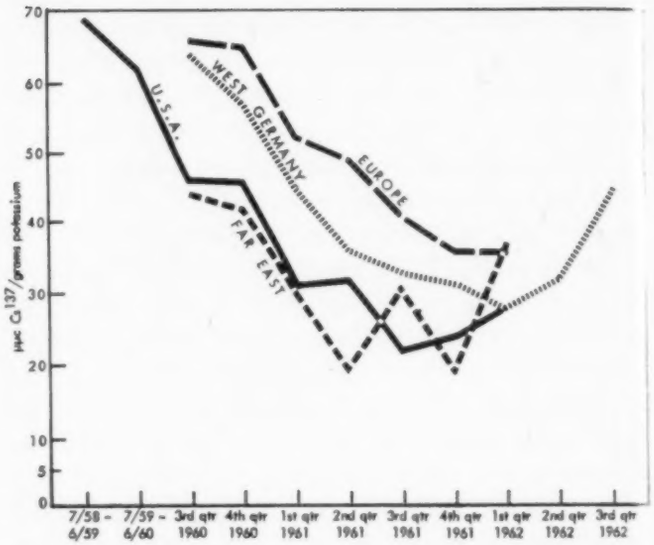

FIGURE 1.—CESIUM–137 BODY BURDENS IN RESIDENTS OF SELECTED AREAS

Figure 1 also shows the effect of the cessation of nuclear weapons testing in the decreasing cesium–137 body burden from 1959 into the first quarter of 1962. Also, the resumption of nuclear weapons testing in 1961 is reflected by the increasing cesium–137 body burden in residents of West Germany in the second and third quarters of 1962. The apparent "spiking" of the cesium–137 body burdens in residents of the far east has not been analyzed for statistical significance.

The maximum value tabulated and plotted, 69 μμc Cs^{137}/gram potassium in the USA for fiscal year 1959, is computed to be 0.32% of the maximum permissible whole body burden of 3 μc* of cesium–137 for the general population (*4*).

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* MPBB for general population = 1/10 MPBB of 30 μc Cesium–137 (occupational exposure).

TABLE 1.—CESIUM-137 IN MAN, JULY 1958–SEPTEMBER 1962

(μμc/gram potassium)

Residence	July 1958 through June 1959	July 1959 through June 1960	Third quarter 1960	Fourth quarter 1960	First quarter 1961	Second quarter 1961	Third quarter 1961	Fourth quarter 1961	First quarter 1962	Second quarter 1962	Third quarter 1962
U. S. A.	69 [a] (906)	62 (744)	46 (147)	46 (164)	31 (170)	32 (75)	22 (61)	24 (80)	28 (104)	[b]	
West Germany			64 (982)	57 (1299)	45 (488)	36 (610)	33 (1305)	31 (1634)	28 (1181)	32 (837)	45 (834)
Europe			66 (36)	65 (40)	52 (32)	49 (11)	41 (5)	36 (14)	36 (7)		
Far East			44 (27)	42 (38)	30 (28)	19 (3)	31 (2)	19 (9)	37 (3)		
Near East			33 (1)	62 (2)	49 (2)						
Central America			58 (1)	59 (2)	28 (1)			24 (1)			
Caribbean				58 (2)	37 (4)	20 (3)					
Pacific Islands				43 (5)	26 (1)		20 (4)				
Canada				55 (1)				26 (2)			
Asia			32 (1)								
Africa			65 (1)		35 (1)						
Greenland			45 (1)								
Australia						36 (1)					
Antarctica					50 (1)						

[a] Numbers in parentheses refer to number of analyses.
[b] Blank indicates no data.

Survey of X-Ray Facilities in Los Angeles

Charles L. Senn,[1] Jack C. Rogers,[2] Joseph Karbus,[3] Raymond A. Miller,[4] Bruce Ault,[4] and Gerhardt Terhoeven[5]
Los Angeles City Health Department[6]

Since 1947, the Los Angeles City Health Department has had legal responsibility for radiological health control as a part of its overall concern with "toxic chemicals." The applicable ordinance subjects to Health Department control any substance which emits ionizing radiation to a degree that may adversely affect the health of exposed persons. The Department's survey in 1956 of shoe fluoroscopy units revealed exposures of children to grossly excessive doses of ionizing radiation. The resulting publicity led to the adoption of corrective measures and to steps toward amending the above ordinance to include authority to regulate and control machines or devices that generate ionizing radiations.

In keeping with its general policy of developing ordinances and rules through the cooperation of advisory committees, the Department organized a radiological health advisory committee to assist the Division of Occupational Health in developing necessary criteria for establishing a radiation control program. The County Medical Society, the Southern California Dental Association, the Los Angeles Radiological Society, several research depart-

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ments from each of four universities, manufacturers and users of radioactive equipment and materials, companies involved in the X-ray equipment and radiation instrumentation field, and other experts served on this radiological health advisory committee. In addition to identifying the areas of concern in radiological health control, it was necessary to determine the extent to which licensed practitioners should be governed and the need for amendment of existing ordinances to cover both materials and machines. The concept agreed upon was that the rules should, among other things, prohibit *unintentional* ionizing radiation. Detailed rules and regulations were adopted, providing for the development of programs and for implementing the inspection work associated with their enforcement.

As one phase of its radiation control program, in July 1962 the Health Department completed initial inspections of approximately 2,700 radiation facilities in the city of Los Angeles. These facilities are divided basically into three major categories: medical, dental, and industrial. The results of the inspections conducted in the medical and dental fields, which accounted for approximately 94 percent of the combined total of all radiation facilities in Los Angeles, are discussed and presented in figures 1 and 2.

SURVEY FINDINGS

Medical X-Ray Facilities

A total of 1,398 medical facilities was inspected, representing 52 percent of all radiation installations in the city. This included approximately 2,000 medical X-ray machines of all types—an average of slightly below 1.5 machines per facility. All medical specialties and installations were covered, including radiologists, general practitioners, chiropractors, veterinarians, podiatrists, and hospitals.

The following factors were considered in the inspection and evaluation of the facilities: (1) size of the primary (useful) beam delivered to the patient; (2) filtration; (3) direction of the primary beam; (4) operator protection; (5) occupancy of adjacent areas; (6) assessment of total exposure to individuals and/or areas.

1. *Beam Size or Collimation.*—Evaluation was guided by the principle that the useful beam should be no larger than necessary for the desired diagnostic or therapeutic purpose. Generally, this means that the beam size should not exceed the size of the film used in a particular X-ray examination. Film ranged in size from 8 x 10 inches to 14 x 36 inches. With a circular cone, a 14 x 17-inch chest film would require a 22-inch diameter beam. Since many X-ray operators have difficulty in centering the beam on the film, it was considered reasonable to make an allowance in beam size of an additional inch on each side. Thus, for a 14 x 17-inch chest film, the beam could be as large as 24 inches in diameter.

Excessively large beams were found in 41 percent of all chest radiography units, 20 percent of trunk radiography units, and 19 percent of units for extremity exposures. Particular importance was attached to trunk exposures, since the reproductive area was frequently exposed, even though not of diagnostic interest. Fewer than 5 percent of the total medical facilities had available and used appropriate gonadal shielding.

Recommendations.—Facilities with excessive beam sizes were given written notice or assistance to correct deficiencies. This generally involved getting a new device (cone) or proper application of available cones. Fewer than 10 percent of all X-ray machines were using new adjustable collimating devices which permit accurate setting of beam size relative to film size and target-to-film distance.

The following future actions are planned:

a. Mark all collimators according to use and application, and educate operators in proper cone use and selection.
b. Require purchase of and application of proper local gonadal shielding.
c. Recommend use of rectangular shutter collimators wherever possible, particularly in new installations.

2. *Filtration.*—Evaluation was based on the standard requirement of 1.5 mm of aluminum equivalent for X-ray machines operating under 70 kvp and 2 to 2.5 mm for units operating at 70 kvp and above (*1*). Approximately 45 percent of medical radiographic facilities were found to have inadequate filtration. Some of the older units with no added filtration had an inherent filtration of approximately 0.5 mm aluminum equivalent. Such machines were

often required to have an additional 2 mm aluminum provided. The range of kilovoltages used in a typical medical facility for the various radiographic techniques involved suggests that not one but two standard filter thicknesses should be applied for the low and high kilovoltage ranges used.

Recommended future activities on filtrations.—

a. Advise selective application of filters in medical offices. A total of 1.5 mm total should be provided in the beam path for techniques below 70 kvp and an additional 1 mm or 2.5 mm total should be provided for over 70 kvp techniques.
b. Determine field method of evaluation of filtration characteristics of X-ray units.
c. Furnish a medical X-ray bulletin.

3. *Operator Protection.*—Eleven percent of all installations were found to have inadequate protection for the X-ray operator. A "suitable protective barrier" was interpreted to mean a built-in booth, a separate room or area, a fixed or portable lead shield, or a means of locating the control button outside of the X-ray room behind a wall of at least two-sided standard plaster. An additional criterion was a provision for the operator to be able to view the patient so that he would not have to leave his protection during exposure.

Tests of a limited number of operations revealed that some operators actually received less than 10 mr/week where an adequate protective barrier did not exist. This was due to limited utilization of the machine; 62 percent of all medical facilities had workloads averaging less than 10 milliampere-minutes per week.

4. *Exposure Record.*—Twenty-one percent of all facilities had employed a personnel monitoring service within the last four years. The majority of these facilities had records indicating that exposures received by X-ray operators were consistently below the permissible average weekly dose of 10 mr (*1*). In practically every case, these facilities had a suitable protective barrier for the operator. An occasional high exposure (over 100 mr per week) could often be attributed to misplacement of the film badge in the X-ray room or to actual exposures resulting from repeated holding of patients and therefore direct beam exposure.

Recommended future activities on exposure record.—In all installations where operator protection is found inadequate, routine pocket chamber exposure tests will be made to determine exposure doses received and thereby to evaluate the significance of hazard.

5. *Exposure and Occupancy in Adjacent Areas.*—In a limited number of cases, field tests were conducted where a potential exposure problem was suspected in an adjacent uncontrolled room or area. Measurements in practically every case indicated that total weekly exposure in the uncontrolled area fell below 10 mr. Where high workloads existed, the rooms generally had heavy lead shielding.

Veterinary X-Ray Usage Facilties

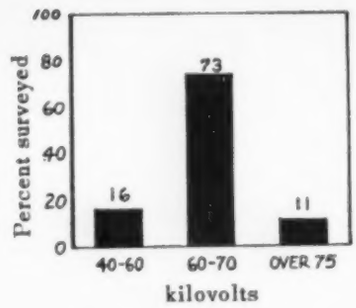
Inspection of veterinary installations indicated that most units were handled acceptably. Collimation could usually be accomplished by adapting some of the dental collimators used in the program. Emphasis was placed on the use of lead aprons and gloves for the operator who must of necessity hold the animal for radiography.

Chiropractic X-Ray Facilities

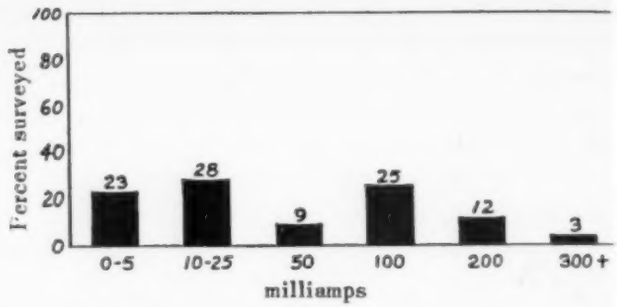
The chiropractic profession in California is licensed in the healing arts and is considered qualified to use X-ray for diagnostic, radiographic, and fluoroscopic work. A major portion of the equipment in use by this group was over 10 years old and generally not up to standards with respect to filtration and collimation. The largest problem was lower spinal X-ray, which immediately involves gonadal exposure. By working with members of this profession experienced in roentgenology, it was possible to promote better standards of protection to both the patient and the operator.

Fluoroscopic Units

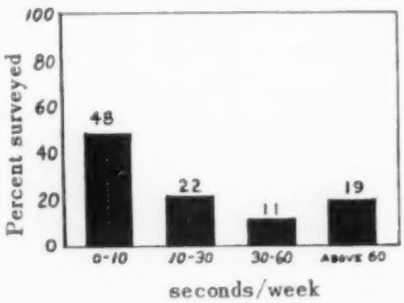
It was noted that many general practitioners had fluoroscopic units, most of them of the upright cabinet type and over 10 years old. Filtration was below standard in most instances. Many of the shutter stops were misadjusted, allowing emergence of the primary beam beyond the edges of the leaded glass screen. The use of fluoroscopy was, however, found to be diminishing to an occasional spot check of short duration, and many had ceased using it entirely. Almost all units used by radiologists were well above minimum requirements (*1*).



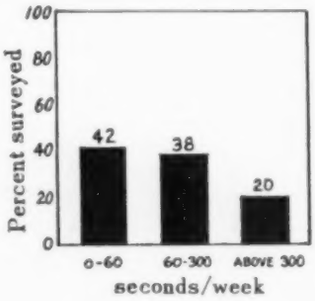
1a.-- Average kv usage



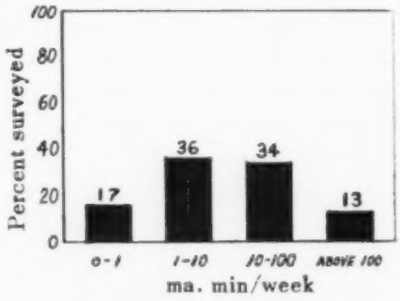
1b.--Ma usage



1c.--Workload (Radiography)



1d.--Workload (Fluoroscopy)



1e.--Workload

FIGURE 1.—SUMMARY OF SAMPLING OF MEDICAL INSTALLATIONS INSPECTED

Photofluorographic Units

A survey of health department X-ray facilities revealed that many photofluorographic units were using blue flourescent screens with a blue sensitive film. Information from the U.S. Public Health Service, confirmed by an equipment manufacturer, had indicated that a green fluorescent screen would result in a 50–60 percent reduction in whole body radiation. Correction of this condition accomplished a substantial reduction in unnecesary ionizing radiation.

Installation Usage and Workload

Figure 1a–e summarizes the usage and workload of medical installations inspected.

Dental X-Ray Facilities

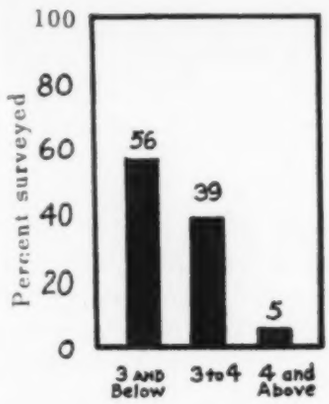
The total number of dental facilities inspected was 1,119, with 1,455 X-ray machines, or an average of 1.3 machines per facility. The program included inspection, assessment and correction, where necessary to reduce unnecessary exposure, based on factors corresponding to those evaluated in the medical program.

1. *Collimation.*—Figure 2a shows the findings with regard to beam size of the dental X-ray units surveyed. Forty-three percent of all units were corrected on the spot for excessive beam size by insertion of a lead collimator which reduced beam diameter to the standard requirement of 2.75 inches (*1*). Twenty-seven percent of all units inspected were found to have an average beam diameter of 3.5 inches, resulting in an exposure area 40 percent larger than needed. Six percent had an average beam diameter of 4.5 inches, resulting in a 62 percent larger exposure area of the face than necessary. Following all corrections, an average area reduction of 27 percent was achieved.

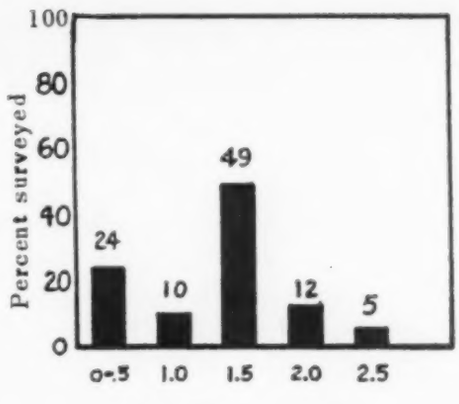
Future activities proposed are:

a. Installation of collimators where necessary.
b. Educational programs to assure their proper use.
c. Continued effort to insure that new equipment is satisfactorily collimated.

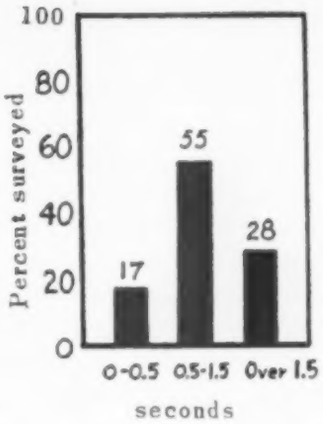
2. *Filtration.*—The distribution of filter thicknesses in mm of aluminum equivalent is presented graphically in figure 2b. Forty-one



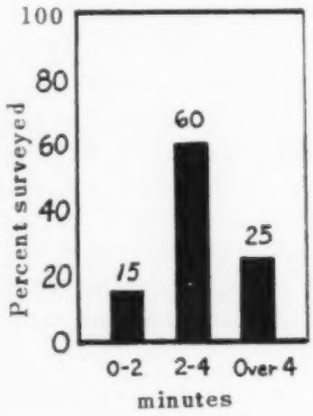
2a.--Collimation



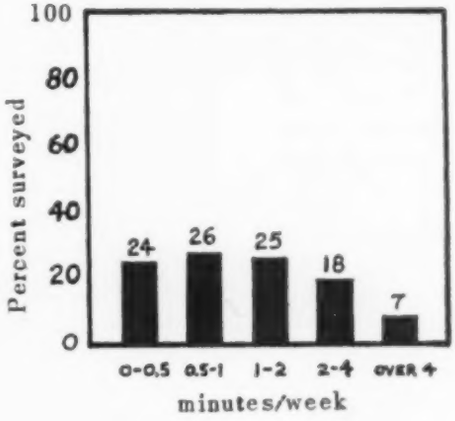
2b.--Filtration



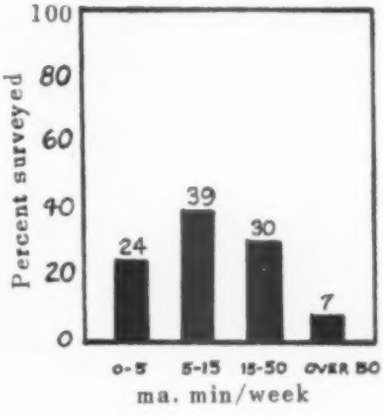
2c.--Exposure time



2d.--Development time at room temperature



2e.--Workload



2f.--Workload

FIGURE 2.—SUMMARY OF SAMPLING OF DENTAL INSTALLATIONS INSPECTED

percent of all dental units had inadequate filtration, based on standards of 1.5 mm aluminum equivalent for 65 kvp units and 2.5 mm for 90 kvp units. Correction was made on the spot by the addition of necessary filtration where needed. The average amount of filtration added to the machines corrected was approximately 0.9 mm of aluminum equivalent. The great majority of corrections were made to the 65 kvp machines found to have only 0.5 mm inherent aluminum equivalent and no added filtration. In these cases, the addition of mm aluminum brought about a reduction of 0 percent in total radiation exposure.

Further activities will be directed to:

a. Determination of a suitable field method to evaluate inherent filtration characteristics of X-ray units.

b. Installation of filters in dental machines that did not previously receive needed filters.

3. *Operator Protection.*—Protection afforded by either a fixed or portable lead shield or by a standard plaster wall was observed in 36 percent of all facilities inspected. Where unnecessary operator exposure was noted, recommendations for change in position were made.

During subsequent visits, operator and area exposure determinations will be made to evaluate if exposure is excessive and/or if film badging is needed.

4. *Exposure and Development Time.*—Of all units inspected, 17 percent had exposure times averaging less than 0.5 seconds and 28 percent more had exposure times averaging 1.5 seconds, as shown graphically in figure 2c.

The first group generally used 90 kvp machines or high speed films or both; in the long-exposure group, many had average exposure times of 3 seconds or longer. The middle group, comprising 55 percent of the total, used predominately 65 kvp machines with mechanical timers and medium speed commercial film. The one-second average exposure of this group is considered reasonable. The use of high speed film would reduce exposure significantly, but the difference in radiographic image appears to present a fundamental objection to dentists who are accustomed to medium speed film.

The control of development factors such as solution quality was in most cases entrusted to a commercial supplier on a monthly basis. As shown in figure 2d, only 25 percent reported a development time of 4 minutes or more at room temperature. The other two groups, representing 75 percent of all facilities, are considered to be underdeveloping; in other words, they were overexposing to produce equivalent film density.

In continuance of the program it is proposed to:

a. Evaluate mechanical timers for accuracy.
b. Increase educational efforts to convince dentists of the value of proper darkroom procedures and equipment to reduce exposure times, including the use of faster film.

5. *Exposure Records.*—A very small percentage of facilities inspected could produce evidence of any cumulative radiation surveillance such as a film badge service. During the survey, limited exposure tests were made, revealing varying degrees of exposure. The requirement for a film badge exists if 25 percent of the MPD (100 mr/wk average) is exceeded.

Future plans include dose studies of personnel and areas, employing pocket chambers of the Division.

6. *Workload.*—The shielding requirement standards of Handbook 76 (*1*) establish a workload figure of 800 ma-minutes for a busy dental installation. Only one facility in the City of Los Angeles approached this workload. Figures 2e and 2f show the distribution of workload in minutes per week and milliamp minutes per week, respectively. Approximately 60 percent of all facilities had a weekly workload below 15 ma-minutes, and only 7 percent exceed 50 ma-minutes per week.

Acknowledgements

The authors acknowledge the services and assistance of: Norman Hume, Director, Los Angeles Bureau of Sanitation, Department of Public Works and his staff; the Industrial Hygienist and the staff of the City's Division of Occupational Health; the Division of Radiological Health, U.S. Public Health Service, and Dr. Clifford E. Nelson of that Division in particular, for his valuable guidance and counsel.

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(*1*) National Committee on Radiation Protection and Measurements: *Medical X-Ray Protection up to Three Million Volts, National Bureau of Standards Handbook 76*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (February 9, 1961), price 25 cents.

(*2*) National Committee on Radiation Protection and Measurements: *Permissible Dose From External Sources of Ionizing Radiation, National Bureau of Standards Handbook 59*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (September 24, 1954), price 35 cents.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

BETTIS ATOMIC POWER LABORATORY

Westinghouse Electric Corporation, Pittsburgh, Pennsylvania
Last Half of 1961 and First Half of 1962

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by Westinghouse Electric Corporation, was established in 1949. Since that time BAPL has been engaged in research and development work related to naval atomic propulsion systems and the central station atomic power reactor at Shippingport, Pennsylvania.

Liquid Radioactive Waste Disposal

The liquid effluent from the Laboratory is sampled continually, and a composite sample is collected and analyzed weekly. This effluent includes the discharge from the Laboratory storm drainage system so that it may include some activity from fallout. The average concentrations of gross radioactivity and strontium–90 are presented in table 1.

TABLE 1.—RADIOACTIVITY IN LIQUID WASTES

[Concentrations in $\mu\mu c$/liter]

Type of activity	Third quarter 1961	Fourth quarter 1961	Average-calendar year 1961	First half 1962
Gross activity[a]	710	310	510	240
Strontium-90	2.1	1.2	1.3	[b]0.5

[a] The environmental MPC for gross radioactivity in water is 2,000 $\mu\mu c$/liter if Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-nat are not present. "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to recent FRC recommendations, a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/5 and if the sum of these ratios for the group in question is equal to or less than 1/4.
[b] First quarter only; second quarter analysis not yet available.

Beta-Gamma Background Levels

Beta-gamma background levels are continuously monitored and recorded at a monitoring station located inside the western boundary of the laboratory property, as shown in figure 1. Averages for 1961 and the first half of 1962, 0.018 and 0.021 millirads per hour respectively, may be compared with the 0.01 to 0.04 mr/hr range measured throughout the United States by the Radition Surveillance Network, Public Health Service, during 1961 and 1962.

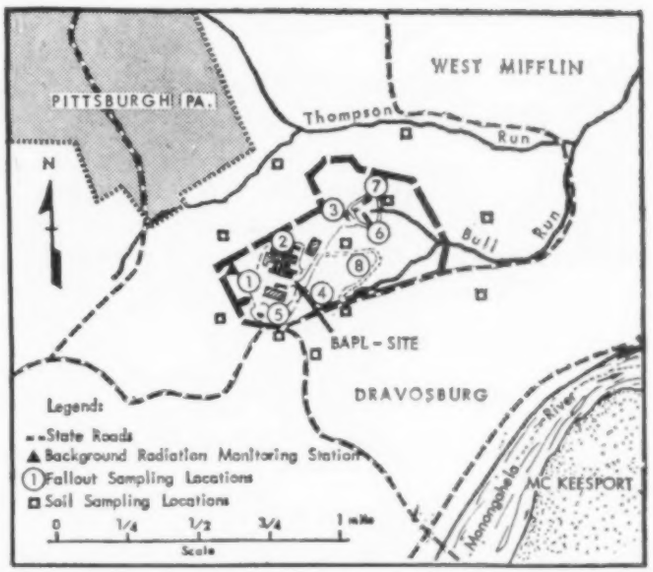

FIGURE 1.—BETTIS ATOMIC POWER LABORATORY SAMPLING STATIONS

Fallout

Monthly fallout samples are collected at the eight stations shown in figure 1. Due to the locations of the stations, the measured activity may include both fallout from the atmosphere and activity resuspended because of the movement of vehicles and construction work. The results presented in table 2 reveal no substantial differences between upwind and downwind fallout rates, but the effect to weapons testing in late 1961 becomes apparent in the fourth quarter data.

TABLE 2.—AVERAGE BETA ACTIVITY IN FALLOUT

(Deposition rates in mc/mi²/mo)

Station (See figure 1)	Third quarter 1961	Fourth quarter 1961	First 5 months 1962[1]
Upwind	13	183	239
Downwind	16	204	273

[1] June 1962 results not available.

Soil Sampling

Soil samples are collected at 11 sampling locations as shown in figure 1 during the second and fourth quarters each year. The fourth quarter 1961 average concentrations in soil based on the eleven samples were 84 $\mu\mu c$ α/g and 43 $\mu\mu c$ ß-γ/g. Soil samples collected during the first half of 1962 had average concentrations of 55 $\mu\mu c$ α/g and 35 $\mu\mu c$ ß-γ/g.

Previous coverage in *Radiological Health Data*:

Period	Issue
1959 and first quarter 1960	*November 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*October 1961*
First and second quarters 1961	*April 1962*

Reported Nuclear Detonations

March 1963

Only one nuclear detonation was announced by the Atomic Energy Commission during the month of March 1963. Arbitrarily referenced by *Radiological Health Data* as test number 101, this test of low yield range was conducted underground at the Nevada Test Site. (Low yield range has been announced as being less than 20 kilotons yield.)

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UNITS AND EQUIVALENTS

For the convenience of the *Radiological Health Data* (*RHD*) reader a selected list of units and equivalents is presented below.

Symbol	Name	Equivalent
Bev	billion electron volts	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	precipitation: $mm = \frac{m\mu c/m^2}{\mu\mu c/liter} \times 1000 = \frac{liter}{m^2}$
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc = 10^{-9} curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 $m\mu c/m^2$ = 1,000 $\mu\mu c/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 μμc = 10^{-12} curies
r	roentgen	
μμc	micromicrocurie	1 μμc = 2.22 dpm

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